



SUPERFUND RECORDS



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July 5, 2005
 Project: 0931G

Missouri-Kansas Remedial Branch
 Superfund Division
 United States Environmental Protection Agency
 901 North 5th Street
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0756 R ENVIRONMENT AND WATER RESOURCES

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| Site: | MISSOURI ELECTRIC |
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| | 7/5/05 |

RECEIVED
 JUL 01 2005
 SUPERFUND DIVISION

Attn: Ms. Pauletta R. France-Isetts, Remedial Project Manager

Re: Groundwater Flow and Transport Supplemental Modeling, 2005, Missouri Electric Works Site, Cape Girardeau, Missouri.

Dear Ms. France-Isetts:

Komex - H2O Science, Inc. (Komex) was commissioned by the Missouri Electric Works (MEW) Site Trust Fund Donors (MEWSTD) to undertake modeling of groundwater flow and transport in the MEW Site area, as documented in the December 17, 2003 draft report by Komex (Komex, 2003). Additional modeling work was commissioned in response to requests made by the United States Environmental Protection Agency (USEPA) at a meeting in Kansas in January 2004, and documented in the July 13, 2004 report by Komex (Komex, 2004a). That modeling interpretation incorporated additional data from off-site boreholes in the wetland area drilled in April 2004. In all, there have been three distinct groundwater models which have undergone revisions in response to new information or in response to USEPA comments. For the purpose of this report the December 2003 model (Komex, 2003) will be referred to as the 2003 model; the July 2004 model (Komex, 2004a) will be referred to as the 2004 model, and the current version of the model will be referred to as the 2005 model.

This report and the January 24, 2005 version of this report (Komex, 2005a) builds on the two previous documents, and incorporates revisions to the 2004 model to accommodate comments from USEPA in their correspondence of November 4, 2004 (USEPA, 2004). This report and the

January 24, 2005 version of this report are a revision of the July 13, 2004 report by Komex. Furthermore, the current version of this report includes additional information in response to USEPA comments on the January 24, 2005 report made in meetings on April 8, April 27 and April 28, 2005.

Objectives

The objectives of the groundwater modeling efforts represented in the 2005 Model were to:

- Revise and modify the 2004 groundwater flow and transport model in response to USEPA (2004) comments;
- Revise model boundary conditions for flow and transport, to improve the representation of site conditions, also in response to 2004 USEPA Comments.
- Improve the definition of the likely nature and extent of Chemicals of Potential Concern (COPC) in the wetland area south of Wilson Road;
- Revise the predictions of distribution and rates of migration of dissolved COPC in off-Site groundwater and in the wetland, for use in the Baseline Human Health Risk Analysis (BHHRA), a final version of the BHHRA was issued in July, 2004 (Komex, 2004d), however in response to USEPA comments the BHHRA is being revised (Komex, 2005b);
- Assess the implications of alternative trichloroethylene (TCE) source concentrations, and alterations to degradation terms in the transport model.

METHODOLOGY

The 2004 groundwater modeling was conducted in accordance with the Draft Work Plan (Komex, 2004b).

Additional information on geology, hydraulic conductivity, water levels and concentrations of COPC was collated and reviewed prior to the 2004 model revision. These data include results from boreholes drilled off-site in April 2004, geophysical work and groundwater monitoring in May 2004, as documented in the Draft Groundwater Remedial Investigation Report submitted in July, 2004 (Komex, 2004c).

The conceptual model of groundwater flow and transport in the MEW Site area developed in 2003 was re-evaluated, and revised as required for consistency with the additional field information. Information from the 2004 boreholes located in the alluvial deposits to the southeast of the MEW site was incorporated into the equivalent porous medium (EPM) model of groundwater flow in the area surrounding the MEW Property, resulting in local modifications to the model's geometry (Komex, 2004a). These fundamental revisions have been retained in the 2005 model.

The discrete fracture model as described by Komex (2003) was used to validate this EPM model, such that the mass flux of COPC from the EPM model corresponded to a best estimate of contaminant mass flux from the discrete fracture model. In addition, the downgradient concentrations in fractures predicted by discrete fracture model were shown to be in reasonable agreement with those predicted by the EPM model (Komex 2003). However, although hypothetical fracture networks can be generated using a discrete fracture model, and both models are capable of predicting COPC concentrations in those fractures, there is no practical way of identifying if, or where an individual fracture truly occurs in the field. Consequently, the results from this EPM modeling must be viewed as representing average conditions, where the scale of the model is sufficiently large that at least one representative elemental volume (REV) of fractured porous media is contained within each EPM model cell. Therefore, each model cell includes a representative number of fractures, and thus simulates the concentration of COPC in those fractures. While this approach simulates groundwater flow and transport in a general sense, it cannot predict the exact migration pathways for COPCs due to the complexity of the fractures.

Key 2004 model revisions are described below, and 2005 model revisions are discussed in Section 2.7.

Solute transport simulations were re-run with the 2004 model geometry to predict possible concentrations and rates of transport of COPC for five specified target locations (Points of Exposure, POE). The COPC concentrations predicted with the 2004 model included two COPC identified from the 2004 BHHRA (1,2,4 trichlorobenzene and total 1,2-dichloroethene). A third COPC identified in the BHHRA (bis [2-ethylhexyl] phthalate) is believed to be a sampling artifact (elevated concentrations in method and field blanks) and therefore has not been simulated in the 2005 modeling iterations. In addition, the expanded list of new COPC compounds, in the BHHRA (Komex, 2005b), which have been evaluated in response to USEPA comments on the 2004 BHHRA, has been simulated with the 2005 model using surrogate compounds to represent groups of COPC with similar transport properties, in terms of retardation by hydrophobic sorption.

Letter Organization

Section 2 of this report presents a brief review of the additional 2004 field data and subsequent modifications to the 2004 conceptual and numerical model;

Section 3 provides the results of new transport scenarios, plus the transport prediction runs, from the 2005 model, and;

Section 4 presents the conclusions from the 2005 groundwater modeling.

DATA REVIEW AND REFINED MODELS

The key information (geological and hydrological) collected in April and May 2004 that was used to develop the 2004 models by refining the 2003 conceptual and numerical models of groundwater flow and transport in the vicinity of the MEW Property are discussed below. A complete discussion of the 2004 field program, and interpretation of the results, is given in the Groundwater Remedial Investigation Report (Komex, 2005c).

DATA REVIEW

The relevant 2004 data in terms of conceptual and numerical model revision were:

- Geology, including depth to bedrock, thickness and lithology of the layers within the alluvium, from drilling boreholes MW-20A-C, MW-21A-B, BH-19A-I and ERT lines 13 and 14;
- Hydraulic properties of the alluvium from slug testing of wells MW-20A, MW-20B, MW-21A and MW-21B, combined with lithological descriptions;
- Water levels from monitoring all wells in May 2004; and
- Concentrations of COPC from monitoring all wells in May 2004.

GEOLOGY

The additional information indicated that:

- There is a zone of thick alluvium, with a maximum proven thickness of 141 feet in the vicinity of MW-16 and 146 feet at MW-20;
- The northern/eastern limit of thick alluvium is defined at the MW-17 location, ERT line 13 and BH-19A-I, which all indicated shallow bedrock at depths ranging from 9.5 to 38 feet below ground surface (bgs), except for BH-19D where bedrock was deeper than 81 feet bgs;
- Alluvial deposits extend to the south, but with a reduced thickness indicated by ERT line 14 and MW-21 (70 feet thick); and,
- There is a significant proportion of clay and silt in the thicker alluvium encountered at well MW-20C. Additional deep alluvium wells MW-16B, MW-16C and MW-21B contain interbedded silt and silty sand.

These data indicate that thick alluvium is more widespread than the small area around location MW-16 assumed in the 2003 model. However, the additional data from location MW-20

supports the maximum thickness of alluvium approximately 140 feet, which was based on data from location MW-16 in the 2003 model.

The existing geologic and geophysical data collected in the wetland area can have several interpretations ranging from a closed geologic depression, to a segment of a larger buried channel feature which may or may not be hydraulically connected to, and part of the Mississippi River Valley system. In any case, the local-scale alluvial groundwater flow systems at the site are controlled primarily by local topography, and the scale of these flow systems from recharge to discharge area is on the order of less than one-half mile. As a result, any lateral continuity of the buried alluvial channel feature would likely have only a minor effect on groundwater flow patterns at the discharge end of the local flow system. Groundwater flow rates into any such buried channel would still be limited by flows through the lower-permeability deposits underlying and down-gradient of the site, and the ultimate groundwater discharge location would likely still be determined by local topography and surface drainage.

HYDRAULIC PROPERTIES

The results of slug tests in wells at locations MW-20 and MW-21 are summarized in Table A.

Table A - Hydraulic conductivity results from 2004 tests

| Well | Lithology of screened interval | Best estimate of Hydraulic Conductivity | | |
|--------|--------------------------------|---|---------|------------|
| | | (m/sec) | (m/day) | (feet/day) |
| MW-20A | Silty sand/clayey sand | 2×10^{-6} | 0.17 | 0.6 |
| MW-20B | Silty sand | 5×10^{-6} | 0.43 | 1.41 |
| MW-21A | Sand- fine to medium grained | 5×10^{-5} | 4.32 | 14.2 |
| MW-21B | Sand- fine to coarse grained | 1×10^{-4} | 8.64 | 28.3 |

These results are consistent with the values of 19.7 feet/day (6 m/day) used for horizontal hydraulic conductivity in the 2003 EPM model, and the revised values of 1.6 to 31.2 feet/day (0.5 to 9.5 m/day) established by the current re-calibration of the 2004 model.

WATER LEVELS

The water levels measured in May 2004, are given in Table B, together with those from October 2003, which were used for calibration of the original 2003 model. A groundwater flow map for the deep alluvium in May 2004 is presented in Figure 1.

As expected, the water levels in May 2004 were higher than October 2003 due to recharge in the winter and spring. Both sets of data show a general flow direction from the MEW site to the southeast towards the creek, with similar hydraulic gradients. As illustrated in Figure 1, the creek acts as a base of drainage in the deep alluvium, separating local-scale groundwater flow systems to the northwest and southeast of the creek. The same pattern is observed in the shallow alluvium. This interpretation is further supported by water level measurements in wells MW-20A and MW-20B, nearest the creek, which indicate an upward gradient (discharge conditions) in the alluvium, although the measured level in well MW-20C is anomalously low. An upward gradient was noted for the MW-16 well cluster during the October 2003 event. A slight downward gradient was noted in the MW-16 well cluster during the May 2004 event. This trend is likely a result of seasonal increase of rain noted during this spring monitoring event. This may also account for the downward trend noted at the MW-21 cluster during the May 2004 event.

Although the water level elevation at well MW-21B is the lowest measured value, it is above the elevation of the water level in the creek, and the flow pattern is consistent with that previously derived from modeling.

Table B - Groundwater elevations - October 2003 and May 2004

| Well ID | Groundwater Elevation October 2003 | | Groundwater Elevation May 2004 | |
|---------|---------------------------------------|---------|-----------------------------------|---------|
| | (feet ASL) | (m ASL) | (feet ASL) | (m ASL) |
| WSW-1 | 367.14 | 111.90 | 368.63 | 112.36 |
| MW-3 | 363.31 | 110.74 | 365.43 | 111.38 |
| MW-4 | 363.64 | 110.84 | 365.61 | 111.44 |
| MW-5 | 363.32 | 110.74 | 365.37 | 111.36 |
| MW-6 | 378.12 | 115.25 | 378.90 | 115.49 |
| MW-6A | 363.60 | 110.82 | 365.53 | 111.41 |
| MW-7 | 363.04 | 110.66 | 365.17 | 111.30 |
| MW-9 | 367.36 | 111.97 | 370.64 | 112.97 |
| MW-10 | 364.67 | 111.15 | 367.20 | 111.92 |
| MW-11 | 363.33 | 110.74 | 365.36 | 111.36 |
| MW-11A | 363.40 | 110.76 | 364.76 | 111.18 |
| MW-12 | 363.30 | 110.73 | 365.42 | 111.38 |
| MW-13 | 363.45 | 110.78 | 365.63 | 111.44 |
| MW-14 | 363.50 | 110.79 | 365.50 | 111.40 |

| Well ID | Groundwater Elevation October 2003 | | Groundwater Elevation May 2004 | |
|---------|---------------------------------------|---------|-----------------------------------|---------|
| | (feet ASL) | (m ASL) | (feet ASL) | (m ASL) |
| MW-15A | 362.73 | 110.56 | 364.85 | 111.21 |
| MW-15B | 362.30 | 110.43 | 364.56 | 111.12 |
| MW-16A | 351.87 | 107.25 | 354.99 | 108.20 |
| MW-16B | 352.77 | 107.52 | 354.94 | 108.19 |
| MW-16C | 353.03 | 107.60 | 354.95 | 108.19 |
| MW-17A | 352.67 | 107.49 | 355.81 | 108.45 |
| MW-17B | 342.03 | 104.25 | 353.62 | 107.78 |
| MW-18 | 353.45 | 107.73 | 355.69 | 108.42 |
| MW-20A | | | 353.35 | 107.70 |
| MW-20B | | | 355.01 | 108.20 |
| MW-20C | | | 286.43* | 87.30* |
| MW-21A | | | 352.35 | 107.40 |
| MW-21B | | | 352.24 | 107.36 |

*: anomalous value, not used for calibration

ASL: above sea level

COPC DISTRIBUTION

The pattern and concentration of COPC from the May 2004 monitoring are very similar to those from October 2003, used for verification of the 2003 model. COPC were not detected in the new wells at locations MW-20 and MW-21. Concentrations of TCE in May 2004 remained similar to previous values, with 8.8 micrograms per liter (ug/l) in monitoring well MW-16B and 8.6 ug/l in well MW-16C. Chlorobenzene concentrations in May 2004 were only found in monitoring wells MW-3, MW-4, MW-5, MW-11 and MW-12.

This COPC distribution is consistent with that used for the 2003 modeling.

2004/2005 CONCEPTUAL MODEL

To incorporate the data described above, the 2004 and 2005 conceptual models include a larger zone of thick alluvium, extending further to the south and east than estimated in the 2003 model and with a reduced vertical permeability to allow for the influence of the greater thickness of silt and clay layers. This feature is interpreted to be either a buried channel or a zone of collapse due to enhanced solution of the limestone bedrock.

2005 NUMERICAL MODEL

The primary aspects of the 2004 conceptual model were represented in the 2005 numerical EPM model to allow evaluation of the implemented changes on groundwater flow and COPC transport. Revisions to the 2004 numerical model were also made to incorporate comments received from USEPA in the review letter of November 4, 2004 (USEPA, 2004). Specific revisions made to the 2004 model to arrive at the 2005 model, in response to USEPA (2004) comments included:

- Change of the southeastern internal boundary condition from no-flow to active cells. The southeastern boundary was relocated to the limits of the model domain, in the upland area to the south and east of the site, and was implemented as a no-flow boundary in the revised location;
- Re-calibrated the flow model using the automated calibration program PEST (Parameter Estimation Program; Doherty, 2004), to improve calibration to the east of the MEW site, and to reflect the revised boundary conditions for flow;
- Revised source area concentrations for the following eight COPC to reflect the maximum concentration observed in groundwater, based on Komex-collected samples (post-soil remediation event). These are the highest quality data available, and reflect higher concentrations than the 95% upper control limit used in the 2003 and 2004 models for the following compounds:
 - Benzene;
 - Chlorobenzene;
 - 1,3-Dichlorobenzene;
 - 1,4-Dichlorobenzene;
 - TCE;
 - Tetrachloroethylene (PCE);
 - 1,2,4-trichlorobenzene; and
 - Total 1,2-dichloroethene.

These eight COPC were all detected in groundwater at concentrations above the toxicity screening levels, as described in the 2004 BHHRA (Komex, 2004d). These eight COPC will be referred to as the "original eight COPC" in the remainder of the report, to distinguish them from the new, COPC discussed below. Elevated concentrations of bis (2-ethylhexyl) phthalate discussed in the 2004 BHHRA have been identified as artifacts of sampling equipment or procedures, since high concentrations were detected in

method and equipment blanks, and thus this COPC was not subject to transport modeling in the 2005 model.

- Transport simulation for additional “new” COPC identified in the 2005 BHHRA (Komex, 2005b);
- Revised source area TCE concentrations in order to reproduce observed TCE concentrations in monitoring wells at location MW-16. This was done as one possible scenario of TCE transport; and
- Revised chlorobenzene transport simulations to include scenarios without first-order degradation (i.e., no half-life terms), as chlorobenzene has the highest groundwater concentrations on site.

The Komex (2004a) report described three versions of the 2004 model, all representing variations on worst-case groundwater flow conditions. All versions were run using MODFLOW 96 for flow and MT3DMS for transport. For the 2005 evaluation, the 2004 model version that predicted the highest concentration values was used (model run MEW16_16-3). That model version has been described by (Komex, 2004a) as:

- Worst case model, with maximum recharge and evapotranspiration, including a deep depression filled with alluvium, enlarged both to include area MW-20 (base of alluvium set at 216.5 feet (66 meters [m]) ASL) and further enlarged to extend as far as area MW-21, representing alluvial deposits in a “channel” shape. This additional zone is shallower (base of alluvium at 285 feet [87 m] ASL) (model run MEW16_16-3), as shown in Figure 2.

For both the 2004 and 2005 models it was assumed that no weathered limestone remains below the medium and deep depression, i.e. that it has been removed by erosion or solution. No bedrock samples were collected at the base of the boreholes for wells MW-16C, MW-20C and MW-21-B, however, the rock cores collected at the location of well MW-17B consisted of a dense limestone bedrock below the wetland area.

Boundary conditions were revised in the 2005 model to accommodate comments by USEPA (2004). The no-flow boundary in the southeast portion of the model was removed, and relocated to the southeast perimeter of the model domain, coinciding with the upland area to the southeast. The revised model boundary conditions are shown in Figure 3.

To reflect the changes to the model boundary conditions, and comments by USEPA (2004) regarding model accuracy, the model was re-calibrated using the automated calibration method PEST. For this recalibration, model recharge rate and boundary heads were held constant, representing worst-case conditions, and hydraulic conductivity was allowed to vary

in order to achieve the optimum calibration. The resulting summary calibration statistics are given in **Table C**. The original and revised hydraulic conductivity values are given in **Table D**. The calibrated hydraulic head distribution showing the groundwater flow pattern for each model layer is illustrated in **Figure 4**.

TABLE C: Summary Statistics, PEST calibration vs. Original Model Calibration

| Calibration Parameter | 2004 Model | 2005 PEST Calibration |
|-----------------------|------------|-----------------------|
| Residual Mean | 1.068732 | -0.01867 |
| Res. Std. Dev. | 0.468992 | 0.360925 |
| Sum of Squares | 32.69141 | 3.526623 |
| Abs. Res. Mean | 1.076232 | 0.269704 |
| Min. Residual | -0.09 | -1.04316 |
| Max. Residual | 2.244584 | 0.474277 |
| Range | 5.61 | 5.61 |
| Std/Range | 0.083599 | 0.064336 |

The calibrated hydraulic head distribution in **Figure 4** shows that the creek is acting as a base of groundwater drainage for all model layers, with particular influence in Layers 1 and 2 (shallow alluvium; deep alluvium/weathered bedrock). That is, there is no appreciable component of groundwater flow from the Site across the creek, to the south/east.

The recharge component was held constant in the calibrations for use in the model. This is a simplification for modeling purposes, recognizing that recharge rate can be affected by numerous factors, including topography, surface drainage pattern, surficial geology, and land use, which could be reflected in a greater rate of recharge on hill tops and flat lands, compared to slopes of hillsides.

TABLE D: Comparison of Calibrated Model Hydraulic Conductivity (K) Values

| K Zone | Layer/Unit | 2005 PEST Calibrated K Value (m/d) | 2004 Model Calibrated Value (m/d) | Percent Difference |
|--------|------------|--|---|-----------------------|
| Kx1 | 1 | 0.06 | 0.08 | 21.32 |
| Kx2 | 2 | 0.53 | 0.3 | -77.93 |
| Kx3 | 3 | 0.36 | 0.1 | -256.24 |
| Kx4 | 1 | 1.11 | 6 | 81.49 |
| Kx5 | 2 | 9.5 | 6 | -58.35 |
| Kx6 | 2 | 526.81 | 200 | -163.41 |
| Kx7 | 3 | 927.03 | 200 | -363.51 |
| Kx8 | 2 | 1.27 | 6 | 78.9 |
| Kz1 | 1 | 0.02 | 0.03 | 44.71 |

TABLE D: Comparison of Calibrated Model Hydraulic Conductivity (K) Values

| K Zone | Layer/Unit | 2005 PEST Calibrated K Value (m/d) | 2004 Model Calibrated Value (m/d) | Percent Difference |
|--------|------------|--|---|-----------------------|
| Kz2 | 2 | 0.46 | 0.3 | -52.4 |
| Kz3 | 3 | 0.01 | 0.1 | 86.73 |
| Kz4 | 1 | 6.51 | 2 | -225.51 |
| Kz5 | 2 | 0.07 | 0.06 | -14.1 |
| Kz6 | 2 | 689.48 | 200 | -244.74 |
| Kz7 | 3 | 126.65 | 200 | 36.68 |
| Kz8 | 2 | 0.09 | 0.06 | -47.21 |

(Note: Kx – horizontal hydraulic conductivity; Kz – vertical hydraulic conductivity)

As a steady state flow model, it is recognized that the calibrated simulation results may not be unique. Simulated head distribution will vary primarily due to changes in recharge rate, which represents real-world units of volume/area and time (e.g., inches per year or millimeters per day). In the absence of this constraint represented by recharge rate, any proportionally scaled hydraulic conductivity distribution would produce a comparable groundwater flow field. However, including the recharge rate as described above limits the combinations of hydraulic conductivity field that match the field-measured heads. The calibration statistics for the PEST-calibrated model given in Table C, particularly the standard deviation divided by the range (Std/Range) of less than 0.10, indicates that the PEST-calibrated model is well-calibrated.

The 2005 transport model was also revised vs. the 2004 model (Komex, 2004a) to include higher source concentrations values, as previously outlined. The revised source concentrations are the maximum concentrations observed in groundwater samples collected by Komex in the vicinity of the Site, as summarized in Table E. As requested by USEPA (2004), this approach recognizes that historic source concentrations were likely higher than present day. A constant source concentration is used in the model. The location of source areas for each of the COPC in Table E is shown in Figure 5.

TABLE E: Revised EPM Model Source Term Concentrations

| Source Area | Chemical of Potential Concern | Source Concentration (ug/L) |
|-------------|-------------------------------|-----------------------------|
| 1 | Benzene | 83 |
| 1 | Chlorobenzene | 3200 |
| 1 | 1,3-Dichlorobenzene | 100 |
| 1 | 1,4-Dichlorobenzene | 120 |
| 2 | TCE | 13 |
| 2 | PCE | 8.6 |

TABLE E: Revised EPM Model Source Term Concentrations

| Source Area | Chemical of Potential Concern | Source Concentration (ug/L) |
|-------------|-------------------------------|-----------------------------|
| 1,2 | 1,2,4-trichlorobenzene | 62 |
| 1 | Total 1,2-dichloroethene | 12 |

The revised modeling for the eight original COPC includes retardation by hydrophobic sorption, as determined by the Koc value and using a retardation factor incorporating the corresponding distribution coefficient, Kd, where Kd equals Koc times the fraction of organic carbon, foc, with foc taken to be 0.2 % (Komex, 2003). In addition, transport simulations for these COPC include first-order degradation, as represented by the half-life for each COPC. The rationale for including degradation in these simulations is discussed in detail in Section 3.1.2.

The fate and transport chemical parameter values used in the model are presented in Table F.

Table F - Chemical Specific Parameter Values for Original Eight COPC

| COPC | K _{oc} (m ³ /kg) | Biodegradation Half Life Used in Model (days) |
|--|---|--|
| Chlorobenzene | 0.219(1) | 150(3) |
| Benzene | 0.0589(1) | 231(5) |
| 1,3-Dichlorobenzene | 0.617(1) | 365(6) |
| 1,4-Dichlorobenzene | 0.617(1) | 365(6) |
| Trichloroethylene (TCE) | 0.166(1) | 300(3) |
| Tetrachloroethylene (PCE) | 0.155(1) | 1019(4) |
| 1,2,4-trichlorobenzene | 0.166 (1) | 360 (2) |
| Total 1,2-dichloroethene | 0.0355 (1,7) | 2875 (2) |
| References for literature data sources: 1. Value taken from USEPA (1996) 2. "High" value quoted in Howard (1989) used as biodegradation half-life 3. Robert et al. 1982 - in Spitz and Moreno, 1996 4. Ellis et al. (1996) 5. Suarez and Rifai, 1999 6. Howard et al., 1991 7. Koc value for cis-isomer is lower than that for the trans-isomer. Value for cis-isomer has been used in the groundwater model, which is conservative Notes: m ³ /kg: cubic meters per kilogram | | |

The number of scenarios included in the 2005 transport simulations was also expanded to address comments by USEPA (2004). The two additional scenarios include one for the TCE source concentration, and one related to degradation as an attenuation mechanism in the transport modeling. These two additional scenarios are described in more detail below.

- **TCE Source Scenario:** For this model run, the TCE source concentration was adjusted by trial and error until the downgradient TCE concentrations at location MW-16 matched those observed in the field. Simulation results for the two model runs (the field-observed maximum source concentration originally run, and the adjusted source concentration to match field values at MW-16) were compared to monitoring well data to assess which version best represented site conditions.
- **Non-degradation Scenario:** The 2003 and 2004 transport model runs (Komex, 2003 and 2004a) for the eight COPC listed above included retardation by both sorption (in alluvial sediments only) and degradation expressed as first order degradation, using a half-life term. To evaluate the suitability of including degradation as an attenuation mechanism, model runs with and without degradation were done for chlorobenzene as it has the highest groundwater concentrations on site. Simulation results were compared with monitoring well data to assess which version best represented site conditions.

EXPOSURE POINT LOCATIONS

Predicted COPC concentrations were derived from the model results to conservatively estimate the off-site reasonable maximum exposure (RME) concentrations at five hypothetical receptor exposure locations referred to as points of exposure (POE), for use in the BHHRA. The five POE locations are shown in **Figure 5**. Four of the five POE locations selected remain similar to those in the previous report (Komex, 2004a), two at the points where the highest COPC concentrations were predicted to reach existing receptors (locations 1 and 2 below), and two at hypothetical well locations where groundwater might be extracted for potable use in a future residential development (locations 3 and 4 below). Location 5, intended to represent a hypothetical well located outside of the plume of impacted groundwater, was relocated to the north and east of its previous location near MW-17, due to the change in plume distribution corresponding to the re-calibrated groundwater flow field.

These point of exposure locations are described in more detail below:

- **Location 1**, where the highest concentration in the groundwater below the wetland area (layer 1) is predicted;
- **Location 2**, where the highest concentration in the groundwater discharging into the wetland creek (layer 1) is predicted;
- **Location 3**, Hypothetical Well A, located 131 feet (40 m) from the MEW property boundary along the interpreted fracture zone, within the weathered limestone (model cell [60,39,2]);

- **Location 4**, Hypothetical Well B, located just south of Wilson Road along the interpreted fracture zone direction, within the weathered limestone (model cell [60,51,2]); and,
- **Location 5**, Hypothetical Well C, outside of the contaminant plume, to the north and east, completed in the weathered limestone (model cell [39,65,2]).

TRANSPORT SIMULATION OF "NEW" COPC

A relatively large number of new COPC were identified for evaluation in the 2005 BHHRA in response to USEPA comments (Komex, 2005b). The groundwater flow and transport model was used to estimate concentrations of these new COPC at the five POE locations discussed above in Section 2.7.1. To facilitate the solute transport modeling, a surrogate compound approach was used. For this approach, the new COPC were grouped according to organic carbon partitioning coefficient (Koc) value. Within each grouping, the most mobile compound, with the lowest Koc value, was used as a surrogate for the COPC within the grouping. This conservative approach produces the highest relative concentration of COPC for the surrogate compound, which is then applied to all COPC in the grouping.

For most of the new COPC, which have not been detected in groundwater, the modeled source concentration was taken to be one-half the maximum Method Detection Limit for the COPC. For the new COPC that have been detected in groundwater, the maximum detected concentration was used for the source concentration, based on data available at the time the modeling study was conducted.

A listing of new COPC for calculation of RME concentrations is given in **Table G**. **Table G** also shows the groupings of COPC by Koc value, the surrogate compound used for each grouping, and modeled source concentration.

TABLE G : New COPC and Surrogates Compounds

| CAS Number | Chemical Name | Source Conc. (ug/L) | Max MDL (ug/L) | Toxicity Screening Value (ug/L) | Koc (L/kg) | Koc Source Reference |
|-------------------|----------------------------------|---------------------|----------------|---------------------------------|-----------------|----------------------|
| 193-39-5 | Indeno(1,2,3-cd)Pyrene | 0.7 | <u>1.4</u> | 0.092 | 3.47E+06 | USEPA, 1996 |
| 53-70-3 | Dibenzo(a,h)Anthracene | 0.65 | <u>1.3</u> | 0.0092 | 1.79E+06 | USEPA, 1996 |
| 205-99-2 | Benzo(b)fluoranthene | 1.215 | 2.43 | 0.092 | 1.23E+06 | USEPA, 1996 |
| 207-08-9 | Benzo(k)fluoranthene | 0.7 | <u>1.4</u> | 0.056 | 1.23E+06 | USEPA, 1996 |
| 50-32-8 | Benzo(a)pyrene | 0.66 | 1.32 | 0.0092 | 1.02E+06 | USEPA, 1996 |
| 56-55-3 | Benz(a)anthracene | 0.71 | 1.42 | 0.092 | 3.98E+05 | USEPA, 1996 |
| 11096-82-5 | Aroclor 1260 filtered | 4.5 | 4.5 | 0.034 | 3.09E+05 | USEPA, 1996 |
| 218-01-9 | Pentachlorophenol | 4.52 | 9.04 | 0.56 | 2.00E+05 | USEPA, 1996 |
| 11097-69-1 | Aroclor-1254 | 0.11 | <u>0.22</u> | 0.034 | 7.56E+04 | RAIS, 2004 |
| 87-68-3 | Hexachloro-1,3-Butadiene | 0.745 | <u>1.49</u> | 0.86 | 5.37E+04 | USEPA, 1996 |
| 53469-21-9 | Aroclor-1242 | 0.1 | <u>0.2</u> | 0.034 | 4.48E+04 | RAIS, 2004 |
| 12672-29-6 | Aroclor-1248 | 0.065 | <u>0.13</u> | 0.034 | 4.39E+04 | RAIS, 2004 |
| 132-64-9 | Dibenzofuran | 0.825 | <u>1.65</u> | 1.2 | 1.13E+04 | RAIS, 2004 |
| 11104-28-2 | Aroclor-1221 | 0.145 | <u>0.29</u> | 0.034 | 1.03E+04 | RAIS, 2004 |
| 11141-16-5 | Aroclor-1232 | 0.175 | <u>0.35</u> | 0.034 | 1.03E+04 | RAIS, 2004 |
| 118-74-1 | Hexachlorobenzene | 0.74 | <u>1.48</u> | 0.042 | 3.38E+03 | RAIS, 2004 |
| 91-20-3 | Naphthalene | 9 | 9 | 0.62 | 2.00E+03 | USEPA, 1996 |
| 91-94-1 | 3,3-Dichlorobenzidine | 0.755 | <u>1.51</u> | 0.15 | 7.24E+02 | USEPA, 1996 |
| 534-52-1 | 4,6-Dinitro-2-Methyl Phenol | 0.485 | <u>0.97</u> | 0.36 | 6.02E+02 | RAIS, 2004 |
| 95-57-8 | 2-Chlorophenol | 9 | 9 | 3 | 3.88E+02 | USEPA, 1996 |
| 75-34-3 | 1,1-Dichloroethane | 31 | 31 | 2 | 3.16E+02 | USEPA, 1996 |
| 56-23-5 | Carbon Tetrachloride | 0.21 | <u>0.42</u> | 0.17 | 1.52E+02 | USEPA, 1996 |
| 98-95-3 | Nitrobenzene | 0.94 | <u>1.88</u> | 0.34 | 1.19E+02 | USEPA, 1996 |
| 88-06-2 | 2,4,6-Trichlorophenol | 0.49 | <u>0.98</u> | 0.96 | 1.07E+02 | USEPA, 1996 |
| 79-34-5 | 1,1,2,2-Tetrachloroethane | 0.235 | <u>0.47</u> | 0.05 | 1.07E+02 | RAIS, 2004 |
| 121-14-2 | 2,4-Dinitrotoluene | 1.185 | 2.37 | 0.0073 | 9.55E+01 | USEPA, 1996 |
| 79-00-5 | 1,1,2-Trichloroethane | 0.165 | <u>0.33</u> | 0.20 | 7.50E+01 | USEPA, 1996 |
| 124-48-1 | Chlorodibromomethane | 0.205 | <u>0.41</u> | 0.13 | 6.31E+01 | USEPA, 1996 |
| 75-27-4 | Bromodichloromethane | 0.19 | <u>0.38</u> | 0.18 | 5.50E+01 | USEPA, 1996 |
| 78-87-5 | 1,2-Dichloropropane | 0.155 | <u>0.31</u> | 0.16 | 4.70E+01 | USEPA, 1996 |
| 67-66-3 | Chloroform | 6.7 | 6.7 | 0.17 | 3.98E+01 | USEPA, 1996 |
| 107-06-2 | 1,2-Dichloroethane | 0.29 | <u>0.58</u> | 0.12 | 3.80E+01 | USEPA, 1996 |
| 621-64-7 | N-Nitrosodi-n-propylamine | 8 | 8 | 0.0096 | 2.40E+01 | USEPA, 1996 |
| 108-60-1 | bis(2-Chloroisopropyl) Ether | 0.87 | <u>1.74</u> | 0.27 | 2.14E+01 | RAIS, 2004 |
| 75-01-4 | Vinyl Chloride | 0.365 | <u>0.73</u> | 0.02 | 1.86E+01 | USEPA, 1996 |
| 111-44-4 | bis(2-Chloroethyl) Ether | 0.84 | <u>1.68</u> | 0.01 | 1.50E+01 | RAIS, 2004 |

NOTE: COPC Groupings separated by heavy bold lines; Surrogate Compounds are shaded
 Bolded COPC detected in groundwater, source concentration = maximum detected concentration

The transport model was used to simulate migration of the surrogate compound, including retardation by sorption in alluvial or loess materials only. Since only one Koc value was used to represent the group of COPC, a single, retarded, contaminant plume distribution was produced. The plume was simulated using relative concentration, C/C_o , where C is the concentration in any location at any time, and C_o is the source concentration. Each COPC in the group has its own C_o value, which was used to calculate the maximum exposure concentration (C) for the COPC at each exposure point. The source concentration for these new COPC was one-half the method detection limit, as given in **Table G**. For all of the new COPC, Source Area 1 was the simulated source area (**Figure 5**) which provides the closest near property location for the additional source compounds to be conservative.

Transport simulations for these new COPC included retardation by sorption, as determined by the Koc value and represented by Kd in the retardation term. These transport simulations did not include degradation as an attenuation mechanism.

MODEL RESULTS

CHEMICAL TRANSPORT

The 2005 flow and transport model was used to predict the concentration of COPC originating from the MEW site in the same manner as the 2003/04 models. The 2005 model was also used to evaluate the two transport scenarios raised through comments by USEPA (2004).

TCE SOURCE CONCENTRATION SCENARIO

The highest historically observed concentrations of TCE in groundwater downgradient of the Site have been present at location MW-16 (wells MW-16B and MW-16C, with maximum TCE concentrations of 9.5 ug/L and 9.9 ug/L, respectively). In contrast, the highest concentrations of TCE in the source area, as represented by wells MW-4 and MW-10, were 5.2 and 13 ug/L, respectively from Komex sampling data, while the maximum historic TCE concentration detected in groundwater at the Site was 19 ug/L (USEPA, 1990). Source concentrations of this magnitude (i.e. 13 ug/L) are not adequate to give the field-observed concentrations at downgradient wells MW-16B (9.5 ug/L) or MW-16C (9.9 ug/L). To reproduce these downgradient TCE levels with the transport model requires a TCE source concentration slightly higher (35 ug/L) than observed in Site groundwater samples. Consequently, the TCE source concentration was adjusted in the transport model until the simulated concentration matched the observed maximum concentration at wells MW-16B/C.

Results of the two simulations are illustrated graphically in Figure 6, which shows the two plume distributions in Layer 2 (weathered bedrock/deep alluvium). The shape of the two plumes is similar, however the higher source concentration produced a slightly larger plume. A comparison of field-observed and simulated maximum TCE concentrations for downgradient monitoring wells is presented in Table H.

TABLE H. Observed vs. Simulated TCE Concentrations, (Original and Increased Source Concentration)

| Well ID | Maximum Observed Concentration (ug/L) | Maximum Simulated Concentration (ug/L) Original Source Concentration (13 ug/L) | Maximum Simulated Concentration (ug/L) Increased Source Concentration (35 ug/L) |
|---------|---------------------------------------|--|---|
| MW-3 | 4 | 6.9 | 18.56 |
| MW-5 | <5 | 0 | 0 |
| MW-7 | 9 | 0.003 | 0.005 |
| MW-11 | 8 | 7.19E-05 | 1.94E-04 |
| MW-11A | <5 | 6.28E-06 | 1.66E-05 |
| MW-12 | <5 | 3.91E-08 | 1.57E-07 |
| MW-15A | <5 | 5 | 14.01 |
| MW-15B | <5 | 4.76 | 12.91 |
| MW-16A | <5 | 0.06 | 0.23 |
| MW-16B | 9.5 | 0.31 | 0.92 |
| MW-16C | 9.9 | 3.75 | 10.1 |
| MW-17A | <5 | 0.04 | 0.18 |
| MW-17B | <5 | 0.14 | 0.54 |
| MW-18 | <5 | 0.38 | 1.03 |
| MW-20A | <5 | 0.01 | 0.02 |
| MW-20B | <5 | 0.09 | 0.23 |
| MW-20C | <5 | 0.02 | 0.06 |
| MW-21A | <5 | 0 | 0 |
| MW-21B | <5 | 0 | 0 |

NON-DEGRADATION SCENARIO

The model used for predicting concentrations at the five POE (described in Section 2.7.1) represents worst-case conditions for groundwater flow, however, the flow model is still reasonably calibrated in terms of field observations. Using worst-case groundwater flow conditions affects primarily the velocity or arrival time of the plume. The transport model was originally conceptualized to qualitatively match the simulated plumes to the observed distribution of contaminants, even though it was not formally calibrated. The transport model was constructed and parameterized with the expectation that degradation would be considered, leading to concentration distribution results that are generally consistent with field observations.

In the absence of degradation, the chlorobenzene simulated plume appears to produce an unrealistic areal extent, or COPC concentrations. As an example of this, shown in Figure 7, chlorobenzene has an un-degraded plume distribution (Figure 7A) much greater in lateral extent than the corresponding simulated plume including degradation (modeled half life 150 days; Figure 7B). The plume including degradation is a better fit with field data, as shown also by comparing the observed vs. simulated maximum concentrations given in Table I. In Table I essentially all cases the results including degradation are much closer to observed than the un-degraded simulation. In addition, the un-degraded simulation predicts detectable concentrations of chlorobenzene in locations where none have been observed, notably locations MW-17, 18, and 20. The results without degradation are commonly orders of magnitude higher than either the observed or degraded simulation results, and therefore are unrealistic. Furthermore, as shown by the data in Table I, the degraded simulation results are in nearly all cases conservative, compared to field data.

Although chlorobenzene has the shortest half-life of the original eight COPCs, the simulation period of 20,000 days is sufficient to allow the plume (with degradation) for all eight of the COPCs to reach steady state. The 20,000 day simulation period represents at least seven, and up to 86, half-lives for the remaining COPCs. The undegraded chlorobenzene plume is a reasonable proxy for the extent of migration for the other chlorinated solvent COPCs, given its intermediate Koc value.

TABLE I. Observed vs. Simulated Chlorobenzene Concentrations, with and without degradation

| Well ID | Maximum Observed Concentration (ug/L) | Maximum Simulated Concentration (ug/L) Degradation Half-Life 150 days | Maximum Simulated Concentration (ug/L) No Degradation |
|---------|---------------------------------------|---|---|
| MW-7 | 9.8 | 0.00 | 0.00 |
| MW-15A | <5 | 137.59 | 541.47 |
| MW-15B | <5 | 1856.80 | 1953.90 |
| MW-16A | <5 | 2.38 | 284.19 |
| MW-16B | <5 | 24.29 | 322.75 |
| MW-16C | <5 | 511.80 | 826.13 |
| MW-17A | <5 | 4.09 | 24.69 |
| MW-17B | <5 | 12.50 | 48.27 |
| MW-18 | <5 | 34.41 | 840.10 |
| MW-20A | <5 | 0.30 | 32.65 |
| MW-20B | <5 | 3.76 | 291.56 |

| Well ID | Maximum Observed Concentration (ug/L) | Maximum Simulated Concentration (ug/L) Degradation Half-Life 150 days | Maximum Simulated Concentration (ug/L) No Degradation |
|---------|---------------------------------------|---|--|
| MW-20C | <5 | 2.82 | 7.74 |
| MW-21A | <5 | 0.00 | 0.00 |
| MW-21B | <5 | 0.00 | 0.00 |

It was never the intent of the transport modeling or the risk assessment to base the analysis on unrealistic data. Consequently, in order to reasonably match the field data, degradation half-life has been included in the transport modeling for the original eight COPC. The new COPC were modeled without including a degradation term.

SIMULATION RESULTS FOR ORIGINAL COPC

The results from the transport modeling of the original eight COPC are illustrated as plume maps in **Figures 8 through 15**, which show the predicted concentrations of the following compounds:

- Benzene (**Figure 8**);
- Chlorobenzene (**Figure 9**);
- 1,3-Dichlorobenzene (**Figure 10**);
- 1,4-Dichlorobenzene (**Figure 11**);
- TCE (**Figure 12**);
- PCE (**Figure 13**);
- 1,2,4-trichlorobenzene (**Figure 14**); and,
- Total 1,2-dichloroethene (**Figure 15**).

The predicted RME concentrations at the POE locations from these simulations are summarized in **Table J**.

Some of the COPC plume maps appear to show a discontinuity in the plume in layer 2 (as illustrated in the B figures). For example, benzene (**Figure 8B**), PCE (**Figure 13B**) and 1,2,4 trichlorobenzene (**Figure 14B**) appear to show a gap within the plume in layer 2. This apparent discontinuity is partially a contouring artifact, since the lower limit of the selected color flood scale does not span the low concentrations in this part of the plume. However, there is also a physical explanation for this effect. In Layer 2 there is a downward component of groundwater flow to the west of the discontinuity, and upward flow in the east. The

apparent discontinuity occurs between the two major flow components, and represents a zone of relatively stagnant flow in Layer 2, whereas more active flow and transport occur in Layer 3. In other words, the core of the plume exits Layer 2 on the upgradient side of the discontinuity, passes downward into Layer 3, then moves upward back into Layer 2 on the downgradient side of the discontinuity.

Table J- Predicted RMEs at specified Points of Exposure (ug/L), Original Eight COPC

| Compound, Original 8 COPC | Units | POE 1 | POE 2 | POE 3 | POE 4 | POE 5 |
|--------------------------------------|-------|-------|--------|---------|---------|----------|
| Benzene | ug/L | 0.562 | 0.0335 | 75.73 | 40.34 | 1.46E-06 |
| Chlorobenzene | ug/L | 507 | 10.91 | 2901.18 | 1351.08 | 2.48E-05 |
| 1,3-Dichlorobenzene | ug/L | 3.42 | 1.97 | 43.99 | 32.98 | 1.64E-05 |
| 1,4-Dichlorobenzene | ug/L | 2.47 | 2.37 | 49.62 | 39.23 | 1.81E-05 |
| TCE, 13 ug/L Source Concentration | ug/L | 2.1 | 0.197 | 5.68 | 5.23 | 7.54E-07 |
| TCE, 35 ug/L Source Concentration | ug/L | 5.74 | 0.512 | 15.25 | 11.6 | 1.20E-06 |
| PCE | ug/L | 0.26 | 0.0413 | 5.39 | 4.32 | 9.48E-07 |
| 1,2,4-trichlorobenzene | ug/L | 2 | 0.125 | 60.52 | 40.53 | 1.96E-06 |
| Total 1,2-Dichloroethene | ug/L | 1.5 | 1.40 | 10.97 | 7.58 | 1.22E-06 |

As previously summarized (Table E) the source of 1,2,4-trichlorobenzene was simulated using the modeled source areas 1 and 2. Source area 1 is located in the southeast corner of the site and source area 2 is located closer to the center of the site, as shown in Figure 5. The locations of these source areas have been described in Komex (2003). The source of total 1,2-dichloroethene was simulated using modeled source area 1.

SIMULATION RESULTS FOR NEW COPC

The predicted relative concentrations (C/Co) for the five surrogate COPC at the five POE locations are presented in Table K.

Table K - Predicted Relative Concentrations (C/Co) for New COPC Surrogate Compounds, at Specified Points of Exposure

| Compound | Koc Group | POE 1 (C/Co) | POE 2 (C/Co) | POE 3 (C/Co) | POE 4 (C/Co) | POE 5 (C/Co) |
|---------------------------|-------------|--------------|--------------|--------------|--------------|--------------|
| Benzo(k)fluoranthene | 106 | 0.000132 | 2.86E-07 | 0.759 | 0.646 | 8.90E-08 |
| Aroclor-1232 | 104 & 105 * | 0.000394 | 6.49E-05 | 0.916 | 0.643 | 8.90E-08 |
| Hexachlorobenzene | 103 | 0.00102 | 0.000206 | 0.916 | 0.643 | 8.90E-08 |
| 1,1,2,2-Tetrachloroethane | 102 | 0.0186 | 0.00344 | 0.209 | 0.394 | 9.47E-07 |
| bis(2-Chloroethyl) Ether | 101 | 0.234 | 0.0152 | 0.936 | 0.643 | 8.90E-08 |

*: Aroclor-1232 also was used as the surrogate for Benzo(a)pyrene.

The predicted RMEs for all new COPC (in alphabetical order) for the five points of exposure are given in Table L.

TABLE L. New COPC RMEs at points of exposure

| CAS No. | CHEMICAL NAME | MODELED SURROGATE | POE 1 (ug/L) | POE 2 (ug/L) | POE 3 (ug/L) | POE 4 (ug/L) | POE 5 (ug/L) |
|------------|------------------------------|---------------------------|--------------|--------------|--------------|--------------|--------------|
| 79-34-5 | 1,1,2,2-Tetrachloroethane | 1,1,2,2-Tetrachloroethane | 4.371E-03 | 8.084E-04 | 4.912E-02 | 9.259E-02 | 2.225E-07 |
| 79-00-5 | 1,1,2-Trichloroethane | bis(2-Chloroethyl) Ether | 3.861E-02 | 2.508E-03 | 1.544E-01 | 1.061E-01 | 1.469E-08 |
| 75-34-3 | 1,1-Dichloroethane | 1,1,2,2-Tetrachloroethane | 5.766E-01 | 1.066E-01 | 6.479E+00 | 1.221E+01 | 2.936E-05 |
| 107-06-2 | 1,2-Dichloroethane | bis(2-Chloroethyl) Ether | 6.786E-02 | 4.408E-03 | 2.714E-01 | 1.865E-01 | 2.581E-08 |
| 78-87-5 | 1,2-Dichloropropane | bis(2-Chloroethyl) Ether | 3.627E-02 | 2.356E-03 | 1.451E-01 | 9.967E-02 | 1.380E-08 |
| 88-06-2 | 2,4,6-Trichlorophenol | 1,1,2,2-Tetrachloroethane | 9.114E-03 | 1.686E-03 | 1.024E-01 | 1.931E-01 | 4.640E-07 |
| 121-14-2 | 2,4-Dinitrotoluene | bis(2-Chloroethyl) Ether | 2.773E-01 | 1.801E-02 | 1.109E+00 | 7.620E-01 | 1.055E-07 |
| 95-57-8 | 2-Chlorophenol | 1,1,2,2-Tetrachloroethane | 1.674E-01 | 3.096E-02 | 1.881E+00 | 3.546E+00 | 8.523E-06 |
| 91-94-1 | 3,3-Dichlorobenzidine | 1,1,2,2-Tetrachloroethane | 1.404E-02 | 2.597E-03 | 1.578E-01 | 2.975E-01 | 7.150E-07 |
| 534-52-1 | 4,6-Dinitro-2-Methyl Phenol | 1,1,2,2-Tetrachloroethane | 9.021E-03 | 1.668E-03 | 1.014E-01 | 1.911E-01 | 4.593E-07 |
| 11104-28-2 | Aroclor-1221 | Aroclor 1232 | 5.713E-05 | 6.786E-09 | 1.328E-01 | 9.324E-02 | 1.291E-08 |
| 11141-16-5 | Aroclor-1232 | Aroclor 1232 | 6.895E-05 | 1.136E-05 | 1.603E-01 | 1.125E-01 | 1.558E-08 |
| 53469-21-9 | Aroclor-1242 | Aroclor 1232 | 3.940E-05 | 6.490E-06 | 9.160E-02 | 6.430E-02 | 8.900E-09 |
| 12672-29-6 | Aroclor-1248 | Aroclor 1232 | 2.561E-05 | 4.219E-06 | 5.954E-02 | 4.180E-02 | 5.785E-09 |
| 11097-69-1 | Aroclor-1254 | Aroclor 1232 | 4.334E-05 | 7.139E-06 | 1.008E-01 | 7.073E-02 | 9.790E-09 |
| 11096-82-5 | Aroclor 1260 filtered | Aroclor 1232 | 1.773E-03 | 2.921E-04 | 4.122E+00 | 2.894E+00 | 4.005E-07 |
| 56-55-3 | Benz(a)anthracene | Aroclor 1232 | 2.797E-04 | 4.608E-05 | 6.504E-01 | 4.565E-01 | 6.319E-08 |
| 50-32-8 | Benzo(a)pyrene | Aroclor 1232 | 2.600E-04 | 4.283E-05 | 6.046E-01 | 4.244E-01 | 5.874E-08 |
| 205-99-2 | Benzo(b)fluoranthene | Benzo(k) fluoroanthene | 1.604E-04 | 3.475E-07 | 9.222E-01 | 7.849E-01 | 1.081E-07 |
| 207-08-9 | Benzo(k)fluoranthene | Benzo(k) fluoroanthene | 9.240E-05 | 2.002E-07 | 5.313E-01 | 4.522E-01 | 6.230E-08 |
| 111-44-4 | bis(2-Chloroethyl) Ether | bis(2-Chloroethyl) Ether | 1.404E+00 | 9.120E-02 | 5.616E+00 | 3.858E+00 | 5.340E-07 |
| 108-60-1 | bis(2-Chloroisopropyl) Ether | bis(2-Chloroethyl) Ether | 2.036E-01 | 1.322E-02 | 8.143E-01 | 5.594E-01 | 7.743E-08 |
| 75-27-4 | Bromodichloromethane | bis(2-Chloroethyl) Ether | 4.446E-01 | 2.888E-02 | 1.778E+00 | 1.222E+00 | 1.691E-07 |
| 56-23-5 | Carbon Tetrachloride | 1,1,2,2-Tetrachloroethane | 3.906E-03 | 7.224E-04 | 4.389E-02 | 8.274E-02 | 1.989E-07 |
| 124-48-1 | Chlorodibromomethane | bis(2-Chloroethyl) Ether | 4.797E-02 | 3.116E-03 | 1.919E-01 | 1.318E-01 | 1.825E-08 |
| 67-66-3 | Chloroform | bis(2-Chloroethyl) Ether | 3.042E+00 | 1.976E-01 | 1.217E+01 | 8.359E+00 | 1.157E-06 |
| 53-70-3 | Dibenzo(a,h)Anthracene | Benzo(k) fluoroanthene | 8.580E-05 | 1.859E-07 | 4.934E-01 | 4.199E-01 | 5.785E-08 |
| 132-64-9 | Dibenzofuran | Aroclor 1232 | 3.251E-04 | 5.354E-05 | 7.557E-01 | 5.305E-01 | 7.343E-08 |

TABLE L. New COPC RMEs at points of exposure.

| CAS No. | CHEMICAL NAME | MODELED SURROGATE | POE 1 (ug/L) | POE 2 (ug/L) | POE 3 (ug/L) | POE 4 (ug/L) | POE 5 (ug/L) |
|--|---------------------------|---------------------------|--------------|--------------|--------------|--------------|--------------|
| 87-68-3 | Hexachloro-1,3-Butadiene | Aroclor 1232 | 2.935E-04 | 4.835E-05 | 6.824E-01 | 4.790E-01 | 6.631E-08 |
| 118-74-1 | Hexachlorobenzene | Hexochlorobenzene | 7.548E-04 | 1.524E-04 | 6.778E-01 | 4.758E-01 | 6.586E-08 |
| 193-39-5 | Indeno(1,2,3-cd)Pyrene | Benzo(k) fluoroanthene | 9.240E-05 | 2.002E-07 | 5.313E-01 | 4.522E-01 | 6.230E-08 |
| 91-20-3 | Naphthalene | 1,1,2,2-Tetrachloroethane | 1.618E-01 | 2.993E-02 | 1.818E+00 | 3.428E+00 | 8.239E-06 |
| 98-95-3 | Nitrobenzene | 1,1,2,2-Tetrachloroethane | 1.748E-02 | 3.234E-03 | 1.965E-01 | 3.704E-01 | 8.902E-07 |
| 621-64-7 | N-Nitrosodi-n-propylamine | bis(2-Chloroethyl) Ether | 1.895E+00 | 1.231E-01 | 7.582E+00 | 5.208E+00 | 7.209E-07 |
| 218-01-9 | Pentachlorophenol | Aroclor 1232 | 1.781E-03 | 2.933E-04 | 4.140E+00 | 2.906E+00 | 4.023E-07 |
| 75-01-4 | Vinyl Chloride | bis(2-Chloroethyl) Ether | 8.541E-02 | 5.548E-03 | 3.416E-01 | 2.347E-01 | 3.249E-08 |
| NOTE: COPC Grouping Surrogate Compounds are shaded | | | | | | | |

COPC LOADING TO SURFACE WATER

The predicted concentration at the wetland creek (POE #2) is a groundwater concentration that discharges to the creek, but is not a concentration in surface water, to which receptors might be exposed. Consequently, the following approach was used to obtain an estimate of COPC concentrations in creek surface water. Concentration data for POE location #2, as presented in sections 3.1.3 and 3.1.4, are retained for comparison purposes, but are not used in the BHHRA.

In this approach, the groundwater flow and transport model was used to estimate the mass loading of COPC to the creek, and subsequently to estimate COPC RME concentrations in surface water in the creek, within or downstream of the COPC plume, for use in the BHHRA.

The mass loading of each of the original eight COPC, in mg/day, to the creek, is given in **Table M**. These values represent the integrated contribution of COPC mass from the entire plume, discharging to the creek. **Table M** also gives mass loading values, in terms of both relative concentrations and actual mass loading/concentrations, for the five surrogate compounds used to represent the new COPC. The relative mass loading for each surrogate COPC can be used to estimate the mass loading, by surrogate group, for each COPC in **Table G**.

The groundwater flow model can also be used to estimate the groundwater discharge to the creek, along various reaches of the creek. As groundwater discharges to the creek, it becomes baseflow, and mixes with runoff or other flows in the creek. Consequently, the baseflow discharge represents the minimum flow in the creek.

The groundwater flow model was used to estimate the groundwater discharge over the area where COPC plumes discharge to the creek. This was done not for each individual COPC plume, but for the overall area where plumes of one or more COPC discharge to the creek, giving one average groundwater discharge value, 499.1 m³/day (**Table M**). The average COPC concentration in the groundwater discharge in this plume area can be estimated by dividing mass load of COPC (mg/day) by the total groundwater discharge over this reach of the creek (499.1 m³/day). These estimated average concentration values are given in **Table M**.

The plume discharge occurs downstream of a reach that receives only un-affected groundwater discharge from upstream of the plume area. These two sources of groundwater discharge combine to give a minimum flow in the creek as it mixes within and downstream of the plume area. As given in **Table M**, this total of upstream discharge and discharge from within the plume area total 1034.3 m³/day. Thus the average concentration of any COPC in the creek is

estimated by dividing the mass loading of COPC by the total baseflow discharge in the creek (Table M). Because the groundwater discharge baseflow component represents a minimum stream flow, the resulting COPC concentration will be conservative, and thus should represent RME concentrations.

Table M. COPC Loading to Surface Water

| COPC | Relative Mass Loading (C/Co) | Mass Loading of COPC to Creek (mg/day) | Groundwater Discharge to Creek in Plume Area (m3/day) | Groundwater Discharge to Creek Upstream of Plume Area (m3/day) | Total Baseflow (Groundwater Discharge) to Creek (m3/day) | Average Concentration in Groundwater Discharge in Plume Area (mg/m3 or ug/L) | Average Concentration in Stream Baseflow Discharge (mg/m3 or ug/L) |
|-----------------------------------|------------------------------|--|---|--|--|--|--|
| Benzene | | 3.774 | 499.1 | 535.2 | 1034.3 | 7.56E-03 | 3.65E-03 |
| Chlorobenzene | | 1406.25 | 499.1 | 535.2 | 1034.3 | 2.82E+00 | 1.36E+00 |
| 1,3-Dichlorobenzene | | 286.76 | 499.1 | 535.2 | 1034.3 | 5.75E-01 | 2.77E-01 |
| 1,4-Dichlorobenzene | | 344.18 | 499.1 | 535.2 | 1034.3 | 6.90E-01 | 3.33E-01 |
| Trichloroethylene (35ug/L Source) | | 30.344 | 499.1 | 535.2 | 1034.3 | 6.08E-02 | 2.93E-02 |
| Tetrachloroethylene | | 0.87 | 499.1 | 535.2 | 1034.3 | 1.74E-03 | 8.41E-04 |
| 1,2,4-Trichlorobenzene | | 3.533 | 499.1 | 535.2 | 1034.3 | 7.08E-03 | 3.42E-03 |
| Total 1,2-Dichloroethene | | 174.27 | 499.1 | 535.2 | 1034.3 | 3.49E-01 | 1.68E-01 |
| Surrogate New COPC | | | | | | | |
| Benzo(k)fluoranthene | 7.78E-06 | 5.45E-06 | 499.1 | 535.2 | 1034.3 | 1.09E-08 | 5.27E-09 |
| Aroclor-1232 | 0.0018 | 3.10E-04 | 499.1 | 535.2 | 1034.3 | 6.20E-07 | 2.99E-07 |
| Hexachlorobenzene | 0.0056 | 0.0041 | 499.1 | 535.2 | 1034.3 | 8.30E-06 | 4.01E-06 |
| 1,1,2,2-Tetrachloroethane | 0.1704 | 0.0400 | 499.1 | 535.2 | 1034.3 | 8.02E-05 | 3.87E-05 |
| bis(2-Chloroethyl) Ether | 0.921 | 0.866 | 499.1 | 535.2 | 1034.3 | 1.73E-03 | 8.37E-04 |

CONCLUSIONS

Revised site geology was incorporated into both the 2004 groundwater flow and solute transport model and the 2005 model. The 2005 model, based on the 2004 model and revised in response to comments by USEPA (2004) includes modifications to boundary conditions, and has been recalibrated using the automated calibration program PEST, which has improved calibration statistics. Both the 2004 and 2005 versions of the model are intended to represent worst-case conditions for groundwater flow, and conservative yet realistic contaminant transport conditions.

The groundwater flow and solute transport model is an EPM model that represents COPC concentrations in fractures downgradient of the Site, for the purpose of calculating worst-case point of exposure concentrations. Although the model can reasonably predict COPC concentrations in a simulated fracture and model results are valid for scales of evaluation that are likely to include one or more fractures, the exact occurrence, location and geometry of fractures in the field are not known. Therefore, model results can be used to assess worst-case risk to hypothetical receptors (by wells modeled as being installed in simulated fractures); however, the results can not be used at the scale necessary to precisely locate wells for either remediation or water supply purposes.

The revised calibrated hydraulic head distribution shows that the wetland creek between locations MW-16 and MW-21 still acts as a base of drainage for all model layers, with discharge of groundwater from the shallow alluvium to the creek.

The re-calibrated groundwater flow causes simulated COPC plumes to be shifted somewhat to the north, compared to previous model versions, giving a better match between simulated plumes and field monitoring well data. A better match is observed particularly with TCE, which now shows better agreement with field data at MW-16. A relatively small increase in on-Site source concentration results in a reasonable match with field measured TCE at location MW-16, but a poorer match at other wells.

Simulations including degradation best represent field-observed plumes. Overall, the modeling approach is conservative, without being un-realistic.

The revised model is suitable for predicting concentrations of COPC at the five hypothetical receptor locations. A surrogate chemical approach for predicting concentrations of new COPC should provide a conservative estimate of concentrations of these COPC at the receptor

locations. Estimates of COPC loading to the wetland creek should provide more representative RME concentrations for COPC in creek surface water.

CLOSURE

This letter report has been prepared for the exclusive use of MEW Site Trust Fund Donors as it pertains to the MEW Site in Cape Girardeau, Missouri. Our services have been performed using that degree of care and skill ordinarily exercised under similar circumstances by reputable, qualified environmental consultants practicing in this or similar locations. No other warranty, either expressed or implied, is made as to the professional advice included in this report. These services were performed consistent with our agreement with our client.

Opinions and recommendations contained in this report apply to conditions existing when services were performed and are intended only for the client, purposes, locations, time frames, and project parameters indicated. We do not warrant the accuracy of information supplied by others or the use of segregated portions of this report.


In regard to geologic/hydrogeologic/chemical conditions, our professional opinions are based in part on interpretation of data from discrete sampling locations. It should be noted that actual conditions at unsampled locations may differ from those interpreted from sampled locations.

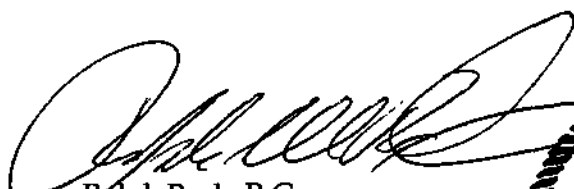
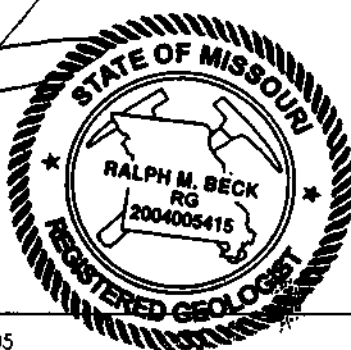
We hope that this is helpful in your assessment. If you have any questions or comments, please contact the undersigned, respectively at (714) 379-1157 extension 161/ mtrudell@losangeles.komex.com; or extension 241/jrohrer@losangeles.komex.com.

Yours sincerely,
KOMEX

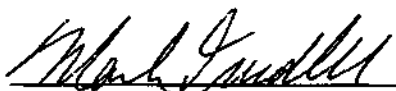


Mark Trudell, Ph.D.
Senior Modeler

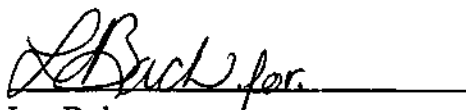

Jon Rohrer, R.G., CHG
Senior Hydrogeologist


Ralph Beck, R.G.
Senior Project Geologist

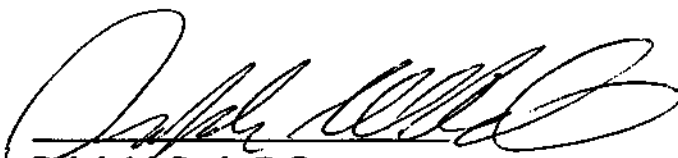
Mark Trudell, Senior Hydrogeologist with Komex, with expertise in hydrogeology and groundwater modeling, and Jon Rohrer, Senior Hydrogeologist with Komex, with expertise in contaminant assessment, remediation and hydrogeology, prepared the letter report with the title "Groundwater Flow and Transport Supplemental Modeling, 2005. Missouri Electric Works Superfund Site, Cape Girardeau, Missouri" dated July, 2005. Ralph M. Beck, a Missouri Registered Geologist, Senior Project Geologist with Komex, reviewed the report. His signature and stamp appear below.



Mark Trudell,, Ph.D.
Senior Hydrogeologist/Senior Modeler
July 2005



Jon Rohrer
Senior Hydrogeologist
July 2005



Ralph M. Beck, R.G.
Senior Project Geologist
July 2005



REFERENCES

- Doherty, J., 2004. PEST: Model-Independent Parameter Estimation Users Manual. Watermark Numerical Computing
- Ellis, D.E. et al, 1996. Remediation technology development forum intrinsic remediation project at Dover Air Force Base, Delaware, in Proceedings of the Symposium on Natural Attenuation of Chlorinated Organics in Groundwater, Dallas, TX, Sept. 11-13, EPA/540/R-96/509, USEPA, Washington, DC.
- Howard, 1989. Handbook of Environmental Degradation Rates. Lewis Publishers, Chelsea, MI.
- Howard, P.H., Boethling, R.S., Jarvis, W.F., Meylan, W.M., and Michalenko, E.M. (1991). Handbook of Environmental Degradation Rates. H.T. Printup (ed). Lewis Publishers, Chelsea, MI
- Komex, 2001. Re-Evaluation of Groundwater Conditions and Conceptual Model Report, Missouri Electric Works (MEW) Site, Cape Girardeau, Missouri. Dated February 12, 2001.
- Komex, 2003. Draft Groundwater Modeling Report, Missouri Electric Works (MEW) Site, Cape Girardeau, Missouri. December 17.
- Komex, 2004a. Groundwater Flow and Transport Supplemental Modeling, 2004, Missouri Electric Works (MEW) Site, Cape Girardeau, Missouri. July 13, 2004.
- Komex, 2004b. Alluvial Channel Subsurface Investigation, Addendum to 2003 Planning Documents for Missouri Electric Works, Cape Girardeau, Missouri. February 27.
- Komex, 2004c. Draft Groundwater Remedial Investigation, Missouri Electric Works (MEW) Site, Cape Girardeau, Missouri. July 30, 2004.
- Komex, 2004d. Final Report for Human Health Risk Assessment, Missouri Electric Works (MEW) Site, Cape Girardeau, Missouri. July 2004.
- Komex, 2005a. Letter from Komex to USEPA RE: Groundwater Flow and Transport Supplemental Modeling 2005, Missouri Electric Works (MEW) Site, Cape Girardeau, Missouri. January 24, 2005

- Komex, 2005b. Baseline Human Health Risk Assessment, Missouri Electric Works (MEW) Site, Cape Girardeau, Missouri. July
- Komex, 2005c. Groundwater Remedial Investigation Report, Missouri Electric Works (MEW) Site, Cape Girardeau, Missouri. July
- Risk Assessment Information System (RAIS) 2004. Oak Ridge National Laboratory, http://risk.lsd.ornl.gov/rap_hp.shtml
- Roberts, P.V., Schreiner, J.E., and Hopkins, G.D., 1982. Field study of organic water quality changes during groundwater recharge in the Palo Alto baylands. Water Res. 16, 1025 – 1035.
- Spitz, K, and Moreno, J., 1996. A practical guide to groundwater and solute transport modeling, Wiley Interscience, New York.
- Suarez, M.P. and Rifai, H.S., 1999. Biodegradation rates for fuel hydrocarbons and chlorinated solvents in groundwater. Bioremediation Journal 3(4) pp337-362.
- USEPA, 1996. Soil Screening Guidance: Technical Background Document. EPA/540/R-95/128, Office of Emergency and Remedial Response, Washington, DC. PB96-963502.
- USEPA, 2004. November 4, 2004 Letter to Mr. Warren Mueller, RE: Draft Groundwater Remedial Investigation and Groundwater Modeling Report: Missouri Electric Works Site, Cape Girardeau, Missouri.

Figures

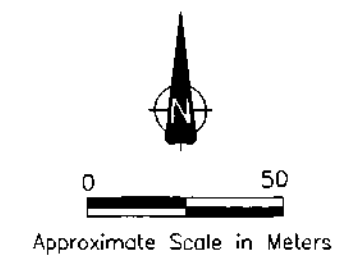
MEW Site File
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FIGURES



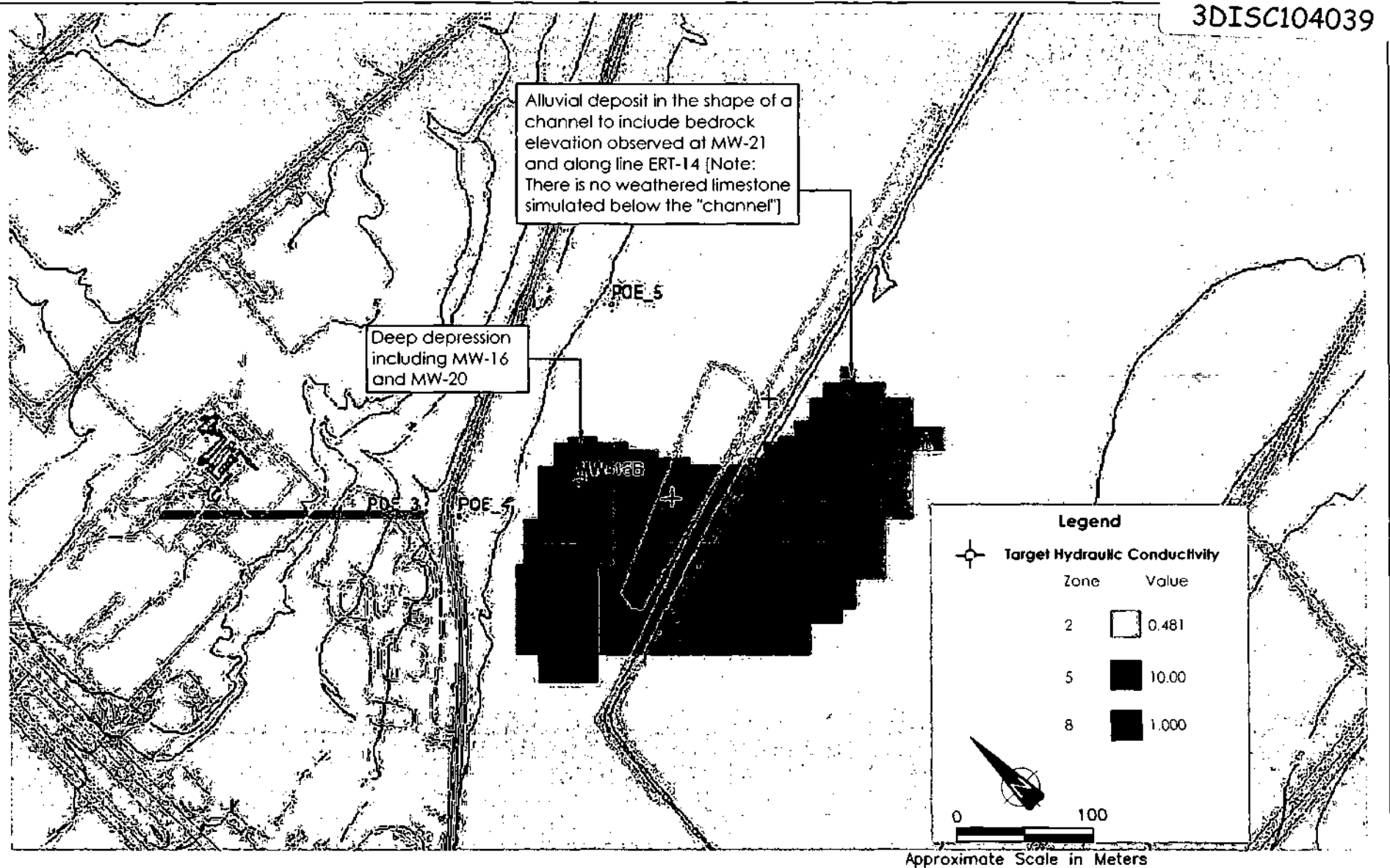
LEGEND

- GROUNDWATER MONITORING WELL
- ⊙ ABANDONED GROUNDWATER MONITORING WELL
- POTENTIOMETRIC CONTOURS
- MEW PROPERTY BOUNDARY
- (354.94) GROUNDWATER LEVEL (FEET ABOVE MEAN SEA LEVEL)
- * CONTOUR INTERPRETATION BASED ON CONCEPTUAL MODEL



| | | | |
|---|--|----|---------|
| MISSOURI ELECTRICAL WORKS CAPE GIRARDEAU | | CI | 04/2005 |
| PIEZOMETRIC SURFACE FOR DEEP ALLUVIAL DEPOSITS FOR MAY 17, 2004 | | JR | H0931G |
| | | 1 | |

MEW Site File
3DISC104038



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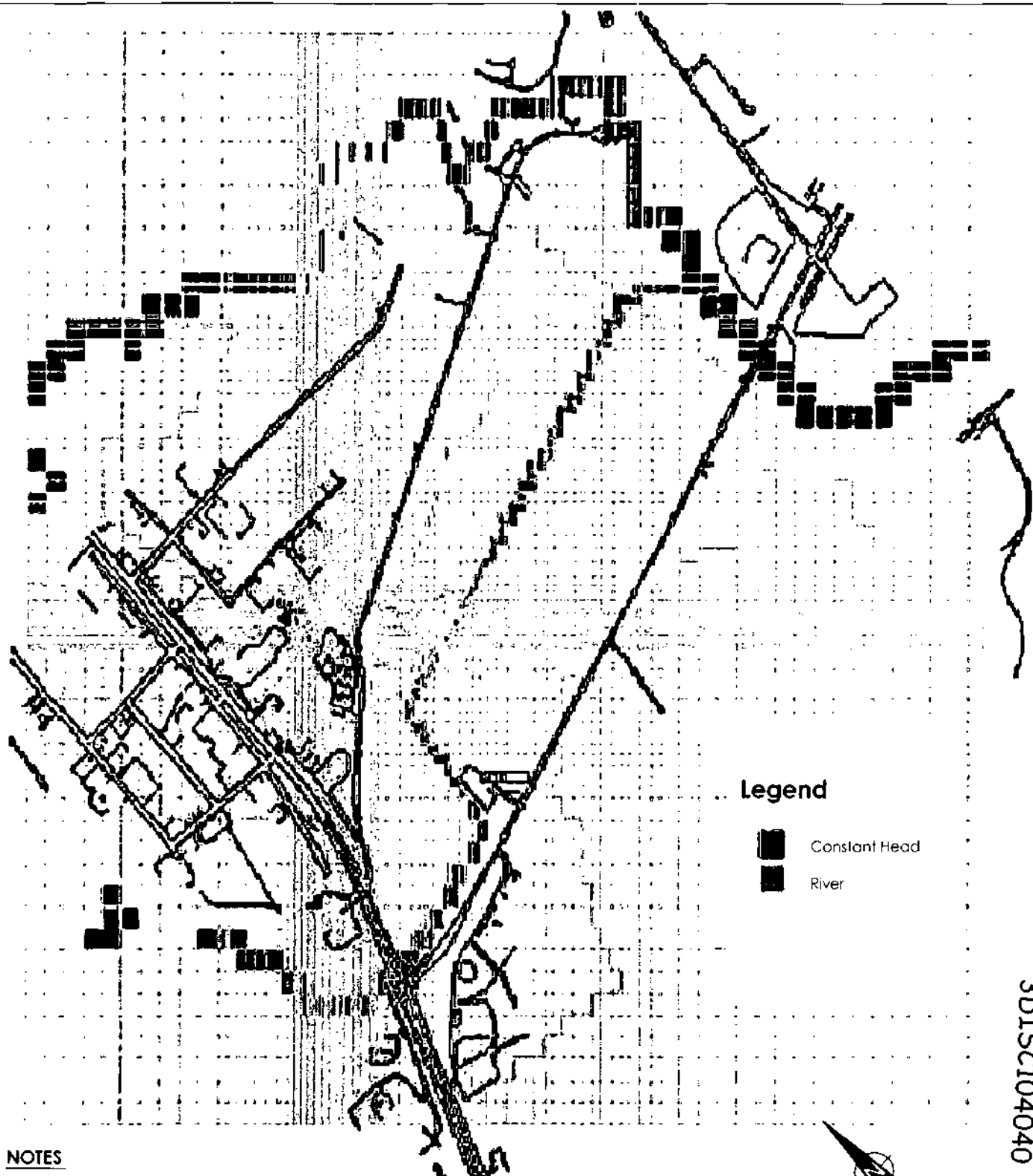
MISSOURI ELECTRICAL WORKS CAPE GIRARDEAU

REVISED MODEL GEOLOGY WITH EXTENSIVE AREA OF THICK ALLUVIUM
(LAYERS 1 AND 2)

CI 01/2005

JR H0931G

2



NOTES

- 1) EDGE OF MODEL DOMAIN IS A NO-FLOW BOUNDARY UNLESS OTHERWISE INDICATED.

0 300

Approximate Scale in Meters



MISSOURI ELECTRICAL WORKS CAPE GIRARDEAU

CT

04/2005

REVISED MODEL BOUNDARY CONDITIONS
(LAYER1)

JR

H0931G

3

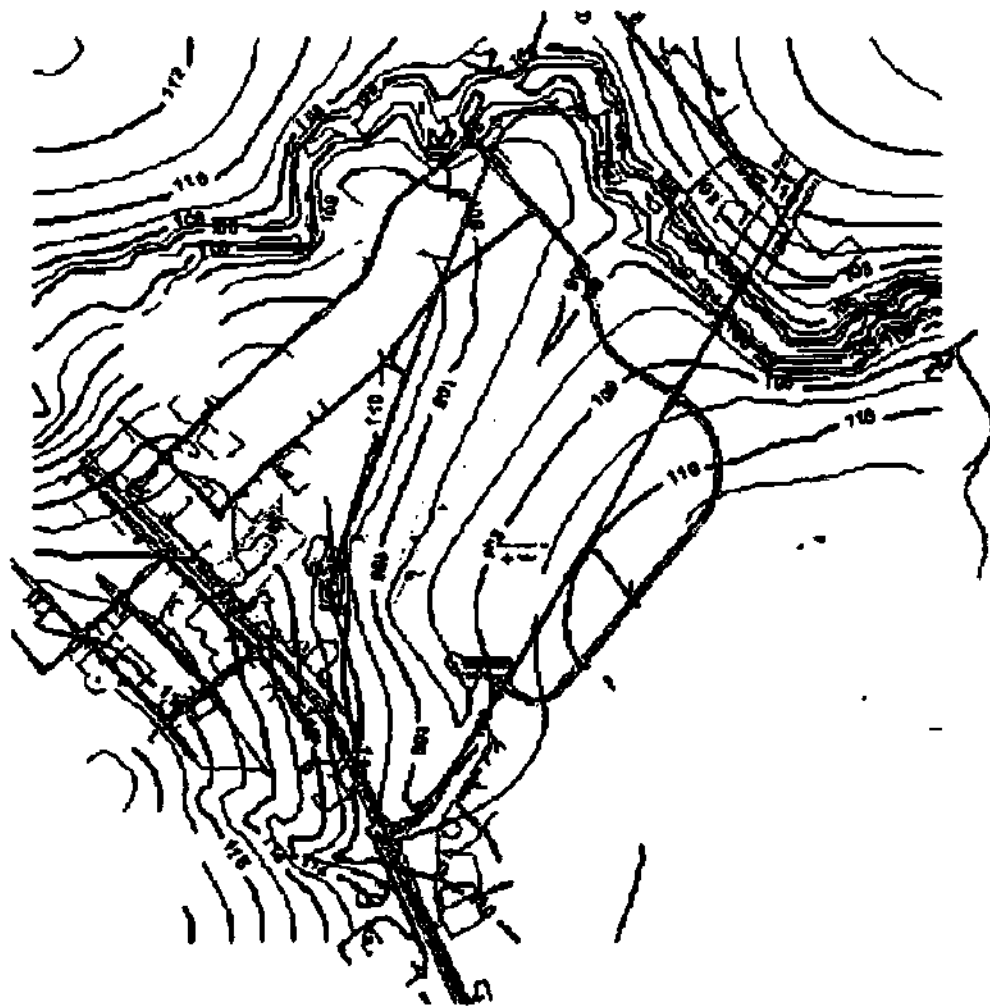


FIGURE 4 (A)

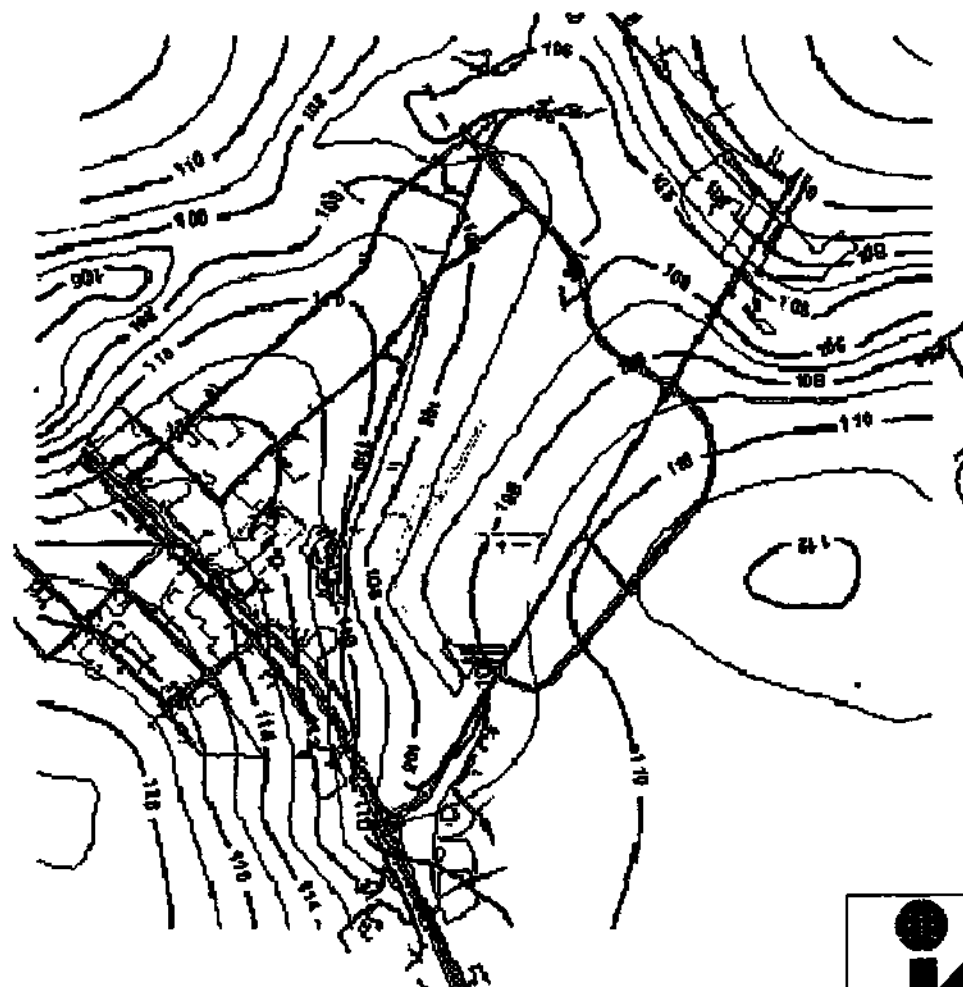


FIGURE 4 (B)

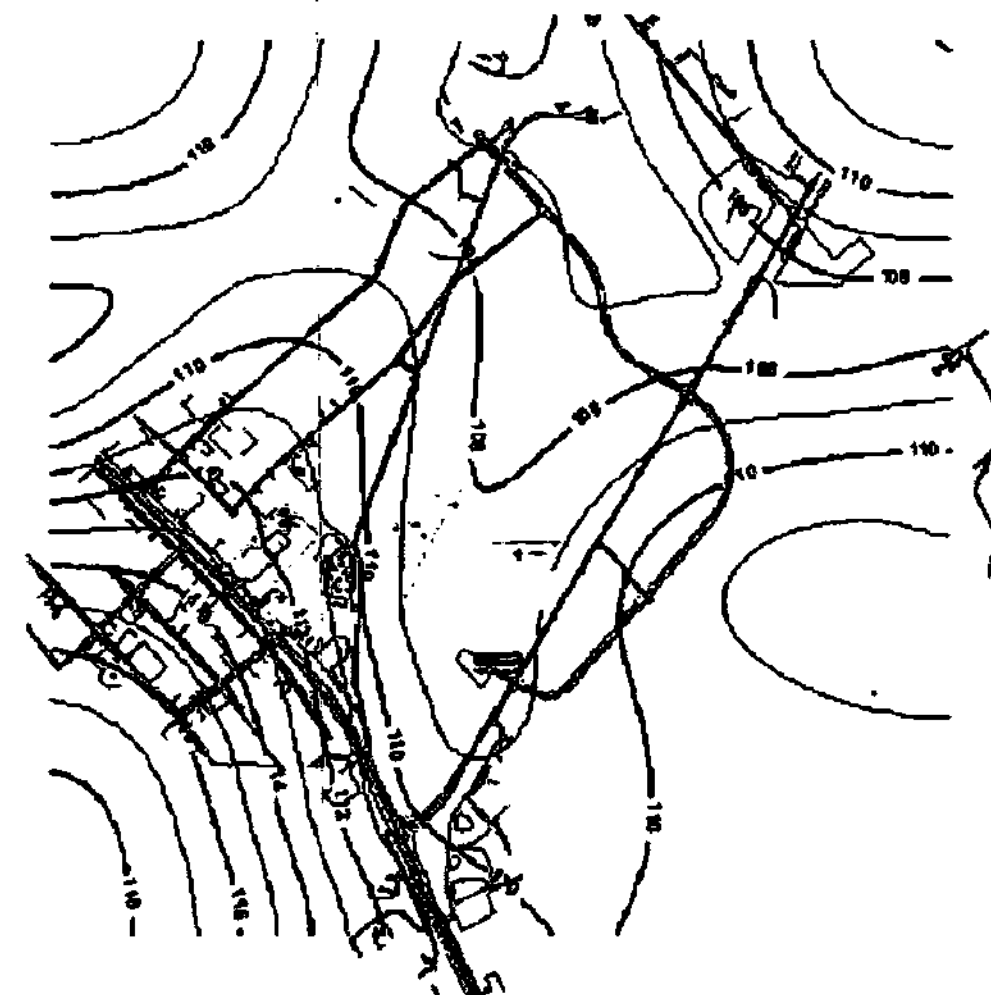
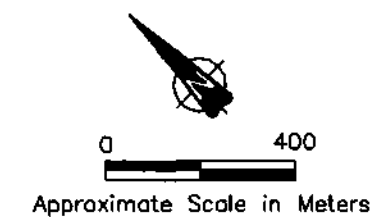


FIGURE 4 (C)

NOTES

1. (A) = shallow alluvium, layer 1; Yellow patches are dry cells.
2. (B) = weathered bedrock/deep alluvium.
3. (C) = fractured bedrock, layer 3.



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MISSOURI ELECTRICAL WORKS CAPE GIRARDEAU

CALIBRATED HYDRAULIC HEAD DISTRIBUTION, METRES
ABOVE SEA LEVEL, CONTOUR INTERVAL 2 M

CT 04/2005

JR H0931G

4

MEW Site File
3DISC104041

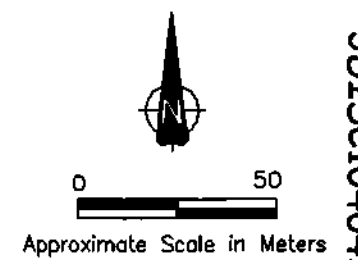


LEGEND

- GROUNDWATER MONITORING WELL
- ABANDONED GROUNDWATER WELL
- POINT OF EXPOSURE LOCATION
- MEW PROPERTY BOUNDARY

NOTES

- SOURCE AREA 1 SHOWN IN GREEN.
- SOURCE AREA 2 SHOWN IN BLUE.



MEW Site File
3DISC104042



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MISSOURI ELECTRICAL WORKS CAPE GIRARDEAU

SITE PLAN WITH LOCATION OF MODELED
SOURCE AREAS

CT 04/2005

JR H0931G

5

NOTES

1. (A) = original source concentration (13 $\mu\text{g/L}$).
2. (B) = source concentration adjusted to 35 $\mu\text{g/L}$ for match at MW16.
3. mg/L = milligrams per liter
4. $\mu\text{g/L}$ = micrograms per liter
5. TCE = trichloroethylene

FIGURE 6 (A)

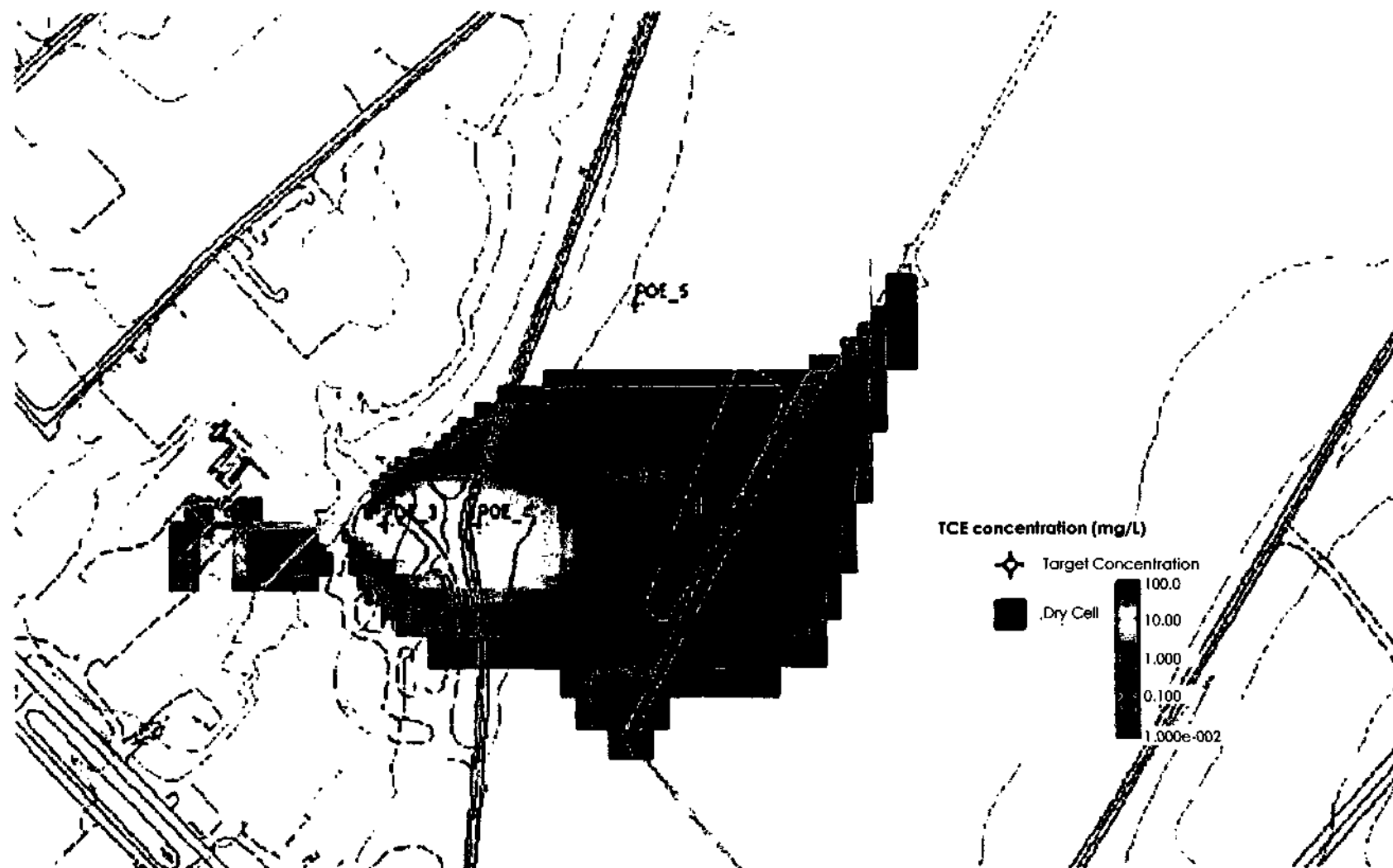


FIGURE 6 (B)

TCE concentration ($\mu\text{g/L}$)

100.0
10.00
1.000
0.100
1.000e-002

0 100
Approximate Scale in Meters



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RESPONSIBILITY OF ANY TYPE IS ASSUMED BY THIS FIRM FOR
ANY OTHER USE NOT BELONGING INTO A CONTRACT

MISSOURI ELECTRICAL WORKS CAPE GIRARDEAU

CT 04/2005

TCE PLUME MAP
FOR TWO SCENARIOS, WEATHERED BEDROCK/DEEP
ALLUVIUM (LAYER 2)

JR H0931G

6

MEW Site File
3DISC104043

NOTES

1. (A) = no degradation.
2. (B) = with degradation.
3. $\mu\text{g/L}$ = micrograms per liter

FIGURE 7 (A)

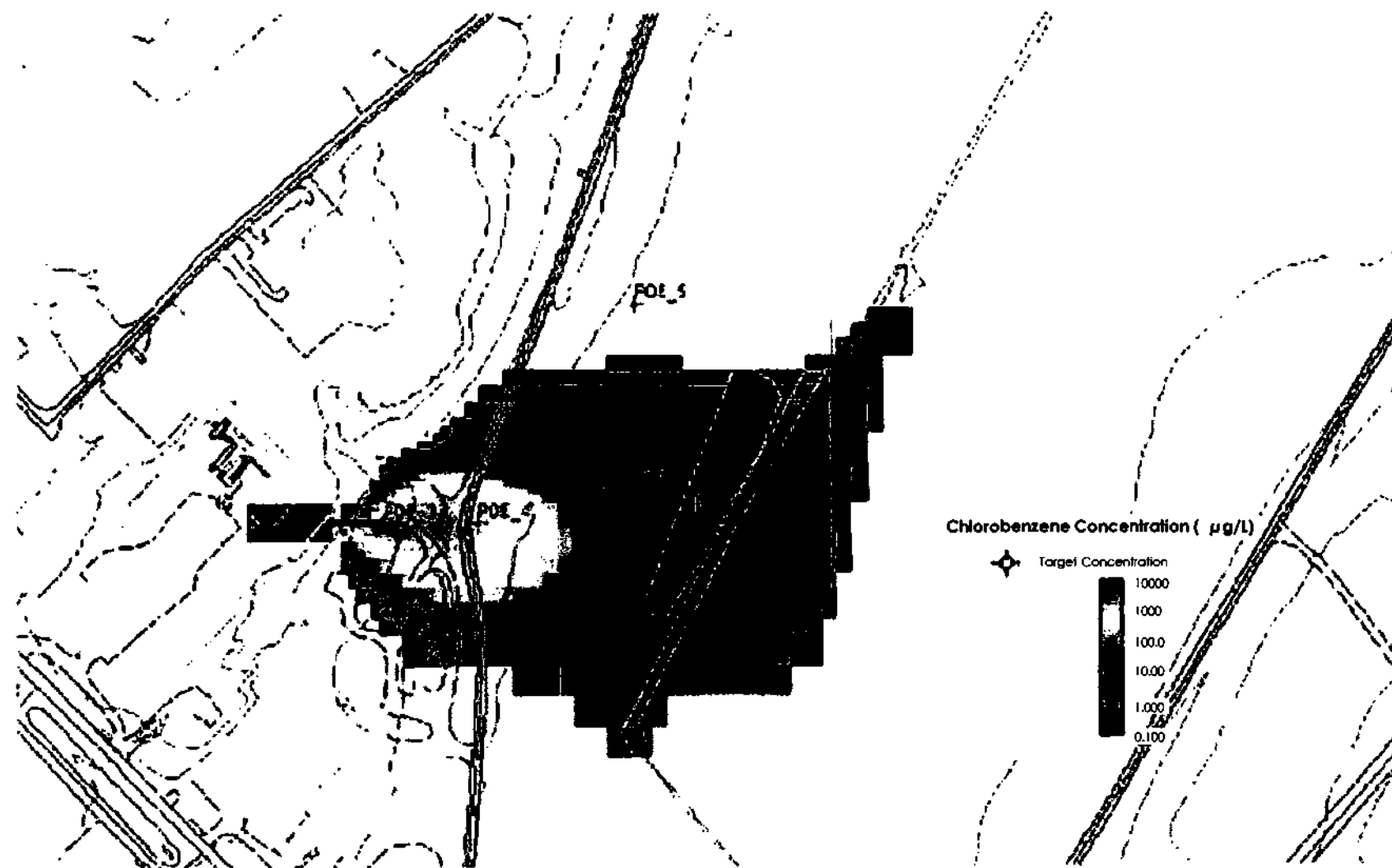
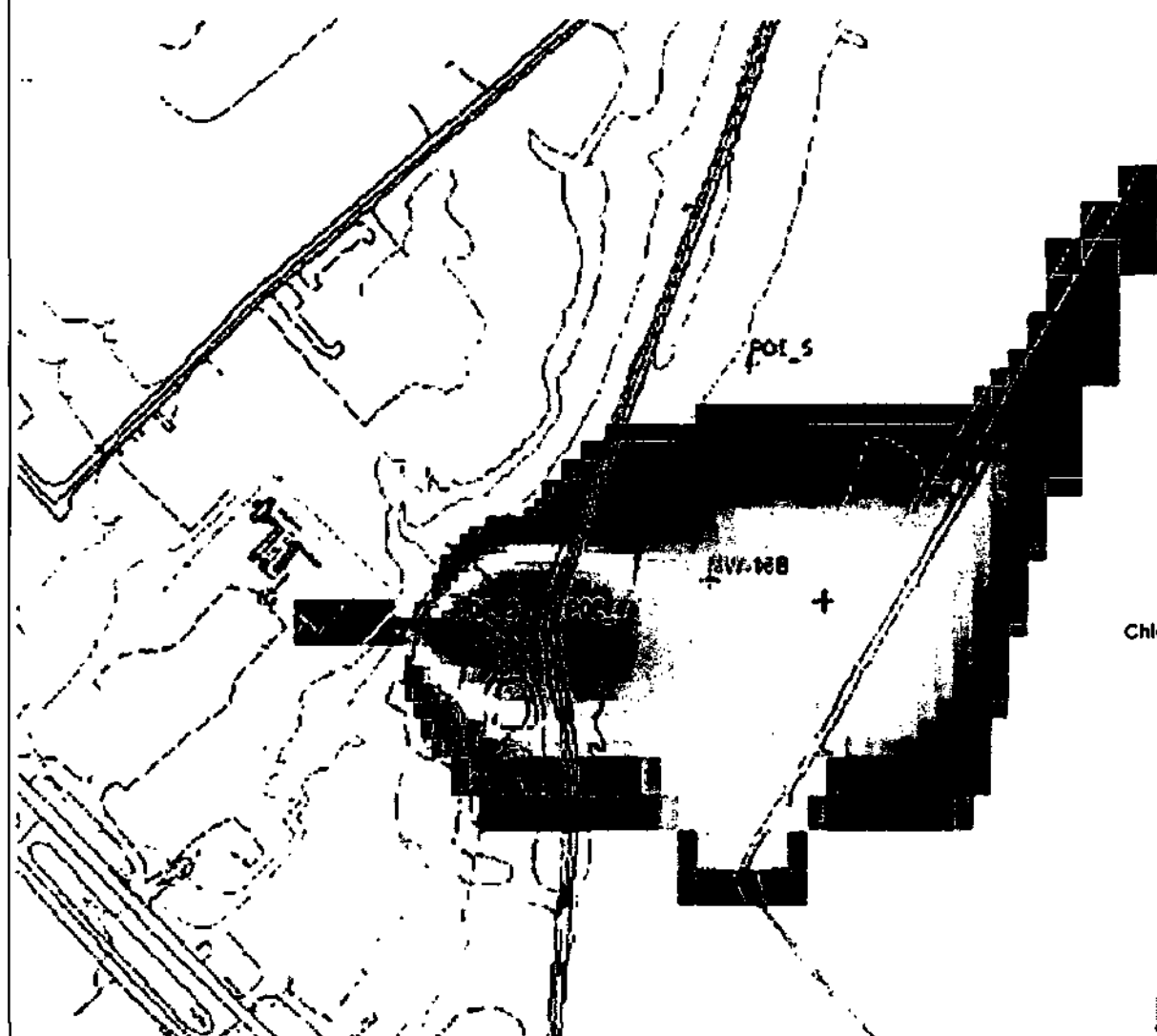
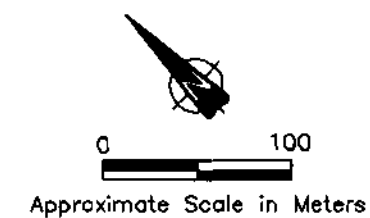
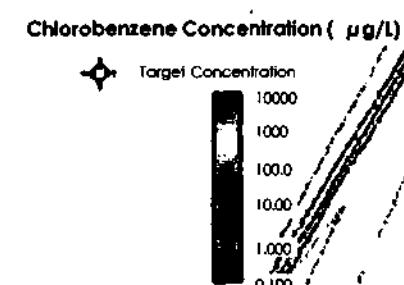
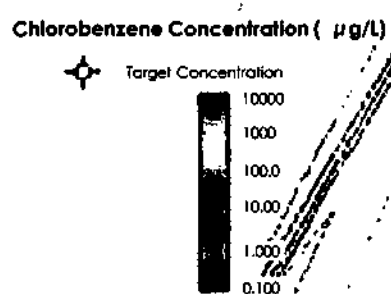


FIGURE 7 (B)



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MISSOURI ELECTRICAL WORKS CAPE GIRARDEAU

CHLOROBENZENE PLUME MAP FOR TWO
DEGRADATION SCENARIOS, DEEP ALLUVIUM
(LAYER 2)

CT 04/2005

JR H0931G

7

MEW Site File
3DISC104044

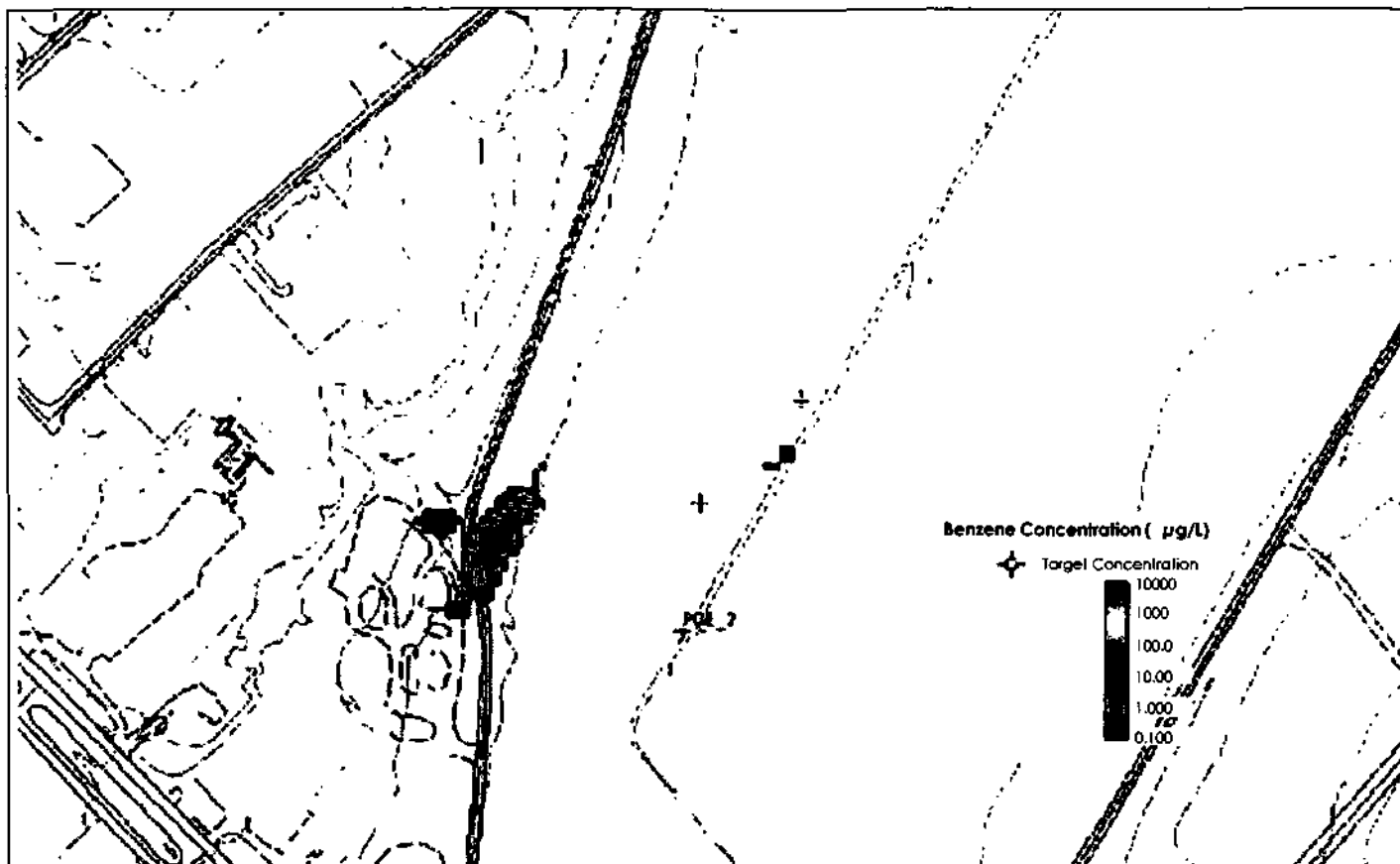


FIGURE 8 (A)

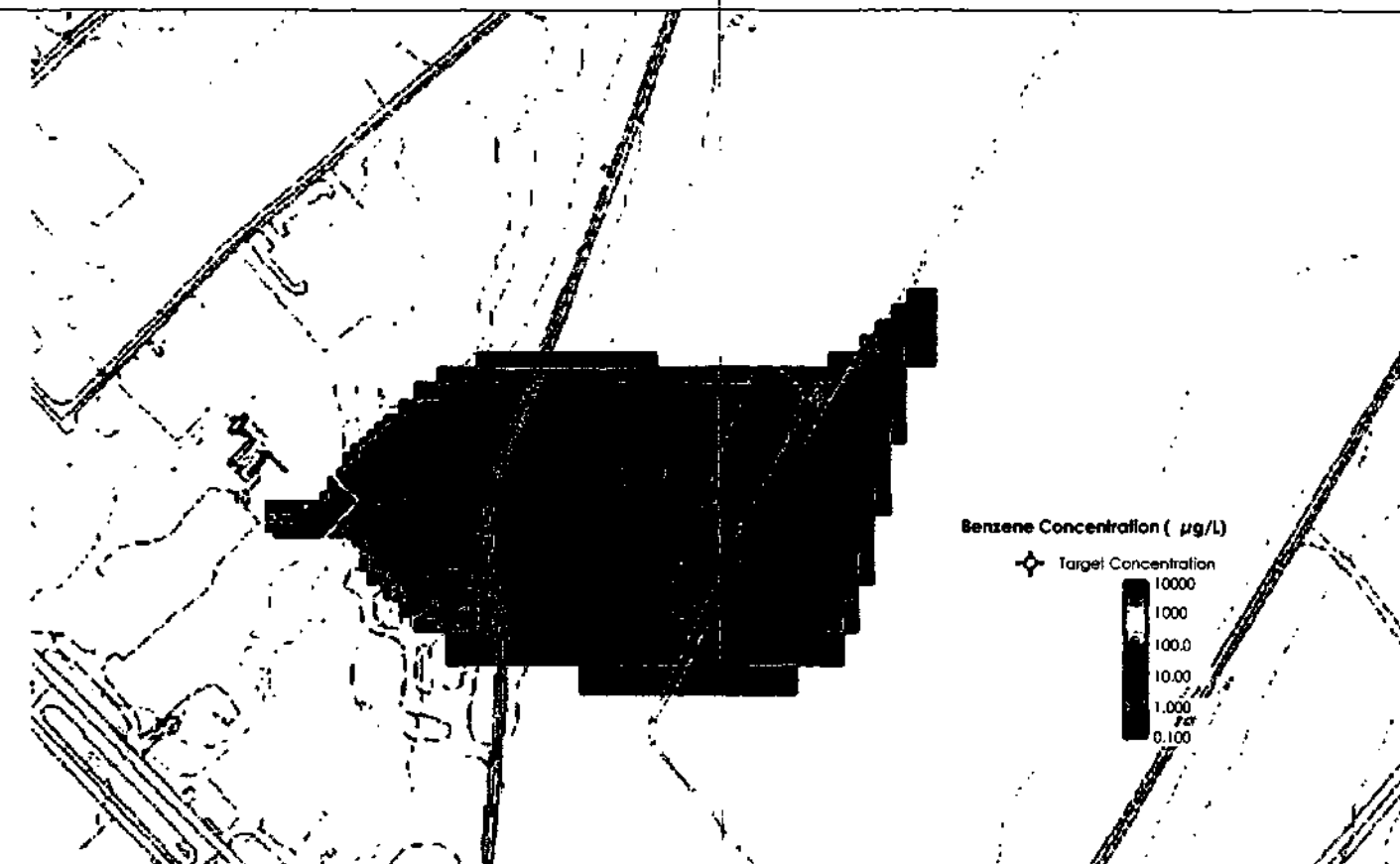


FIGURE 8 (C)

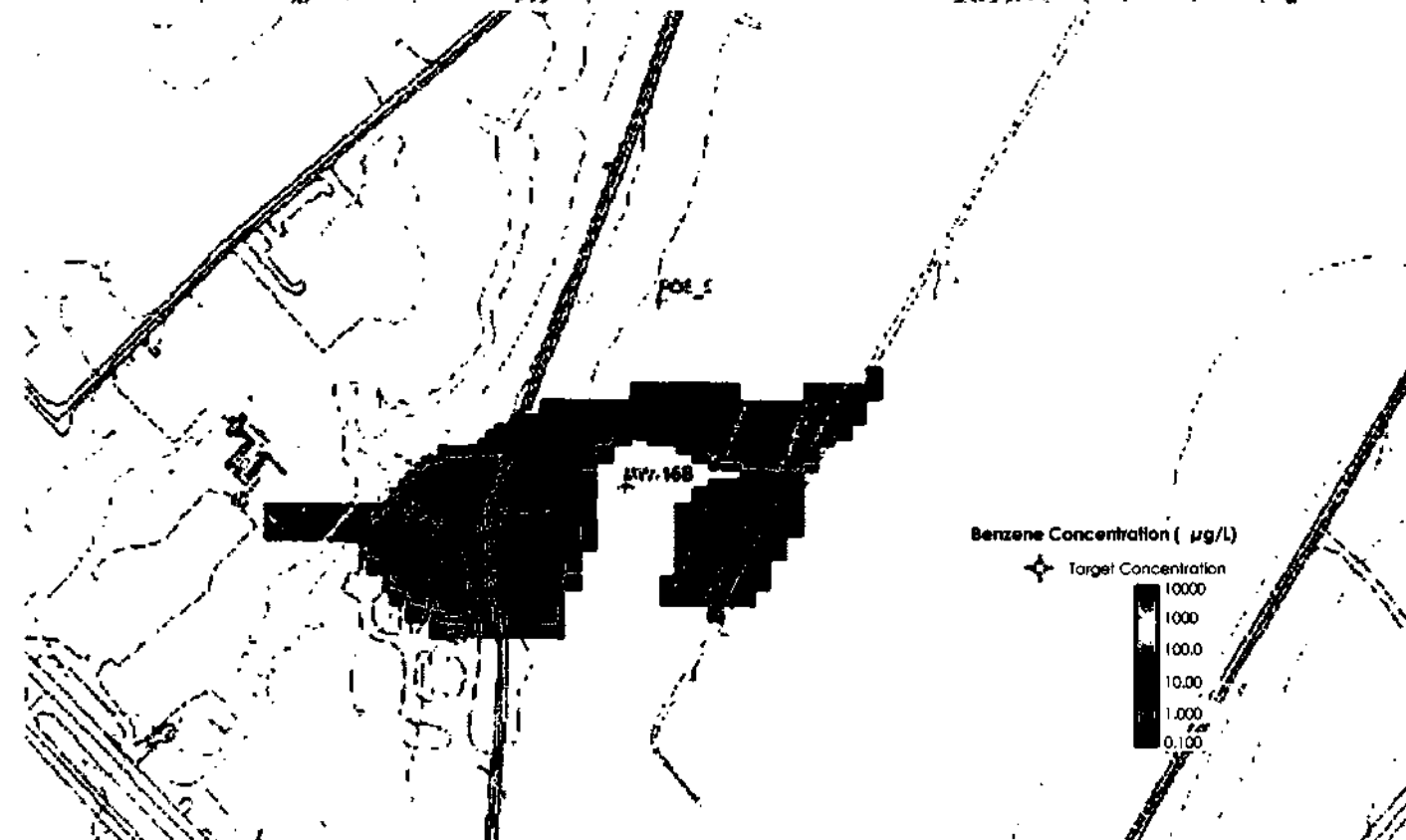


FIGURE 8 (B)

NOTES

1. (A) = shallow alluvium, layer 1.
2. (B) = weathered bedrock/deep alluvium, layer 2.
3. (C) = fractured bedrock, layer 3.
4. µg/L = micrograms per liter



Approximate Scale in Meters



MISSOURI ELECTRICAL WORKS CAPE GIRARDEAU

BENZENE PLUME MAP

| | |
|----|---------|
| CT | 04/2005 |
| JR | H0931G |

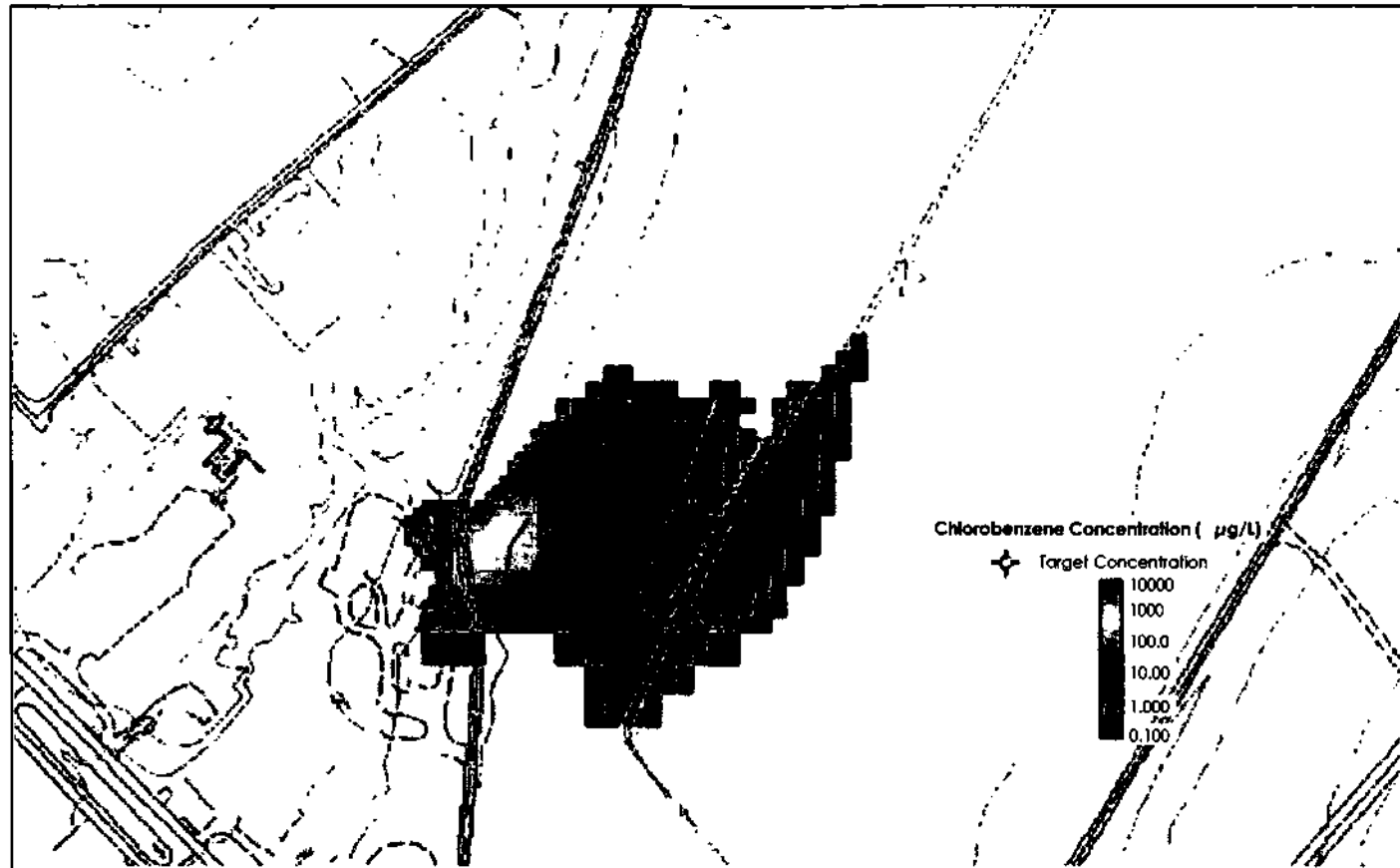


FIGURE 9 (A)

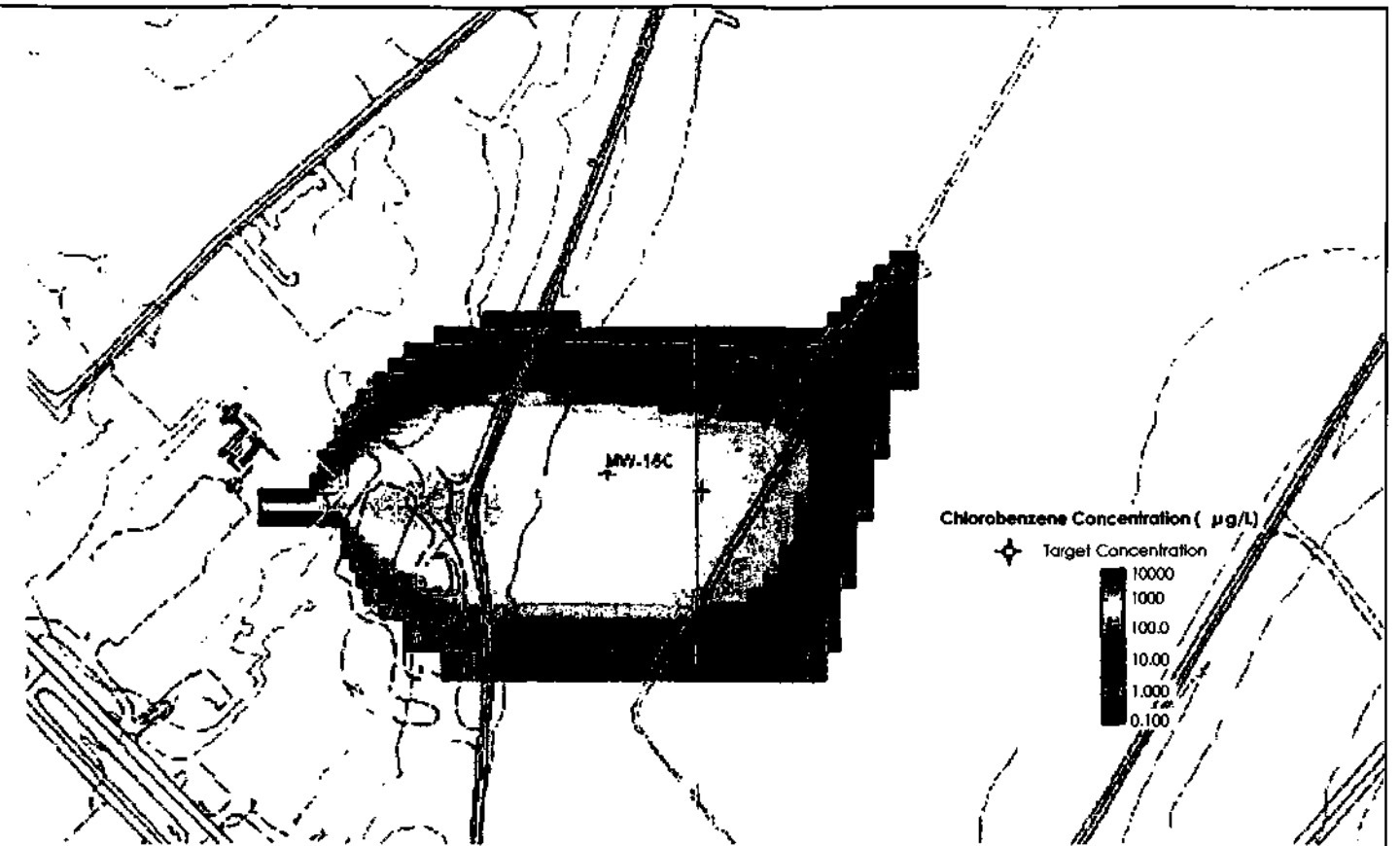


FIGURE 9 (C)

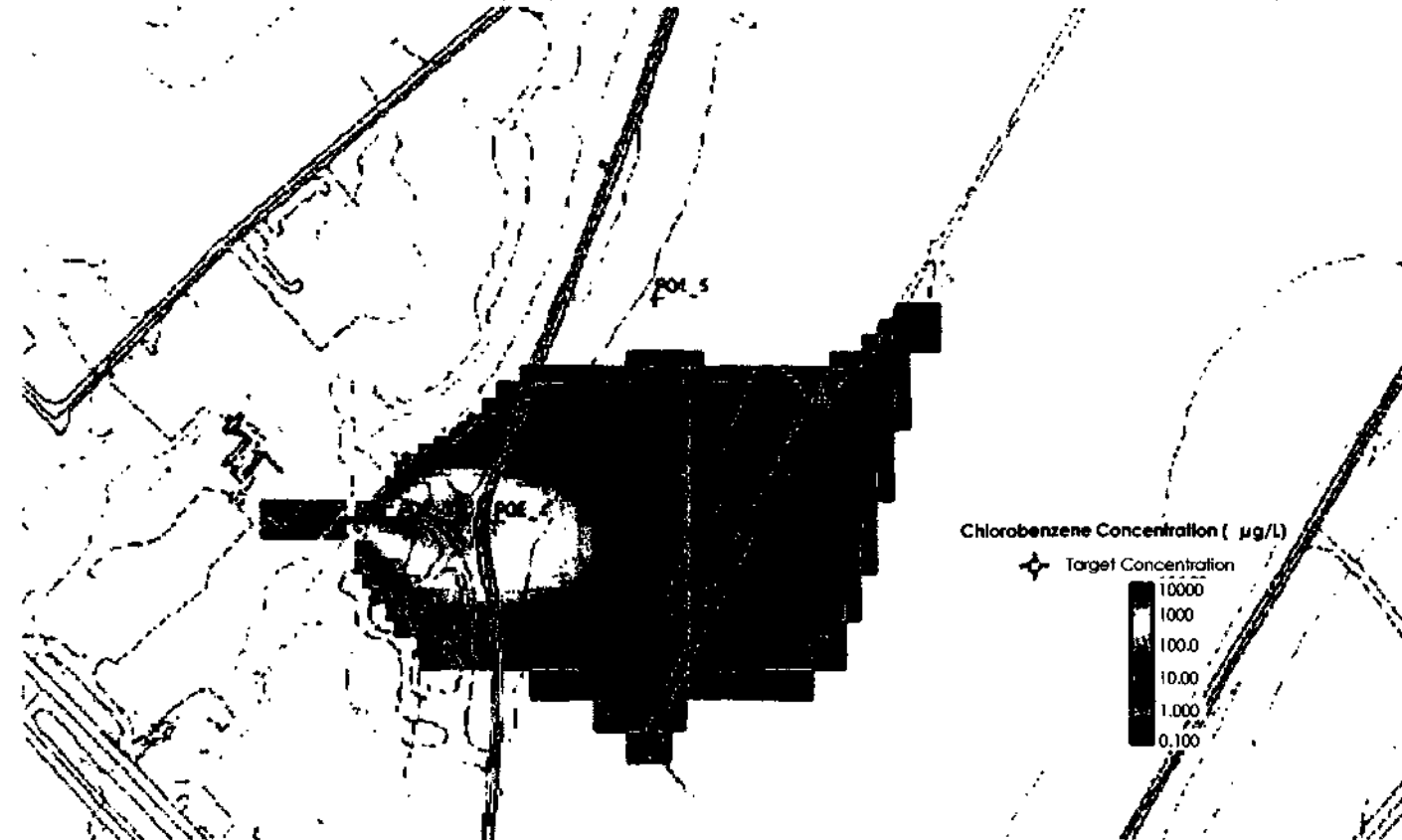
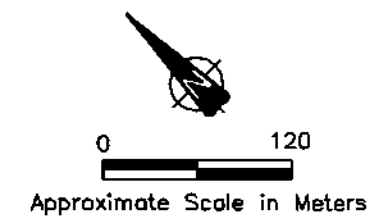


FIGURE 9 (B)

NOTES

1. (A) = shallow alluvium, layer 1.
2. (B) = weathered bedrock/deep alluvium, layer 2.
3. (C) = fractured bedrock, layer 3.
4. µg/L = micrograms per liter



MISSOURI ELECTRICAL WORKS CAPE GIRARDEAU

CHLOROBENZENE PLUME MAP

CT 04/2005

JR H0931G

9

MEW Site File
3DISC104046

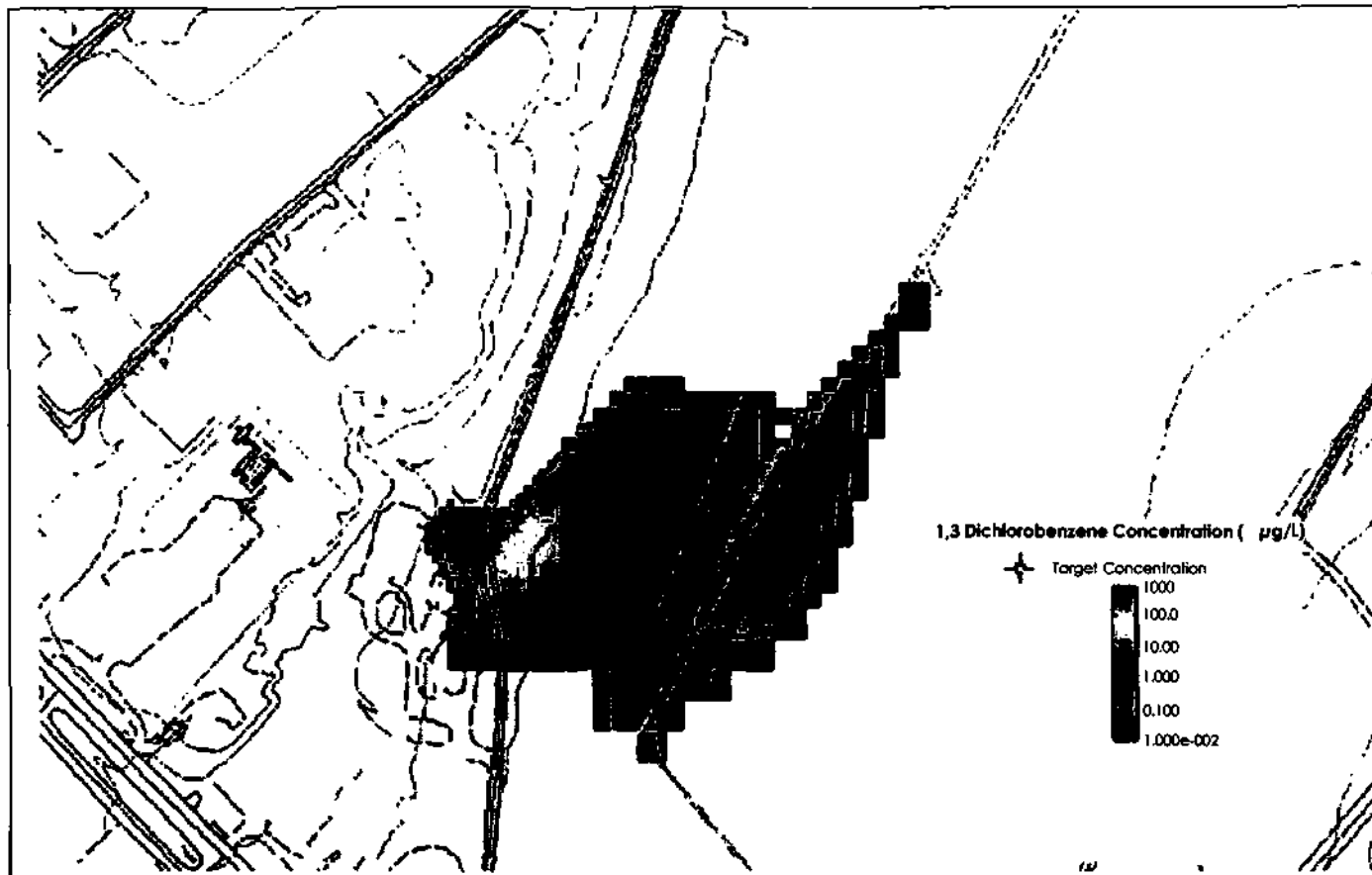


FIGURE 10 (A)

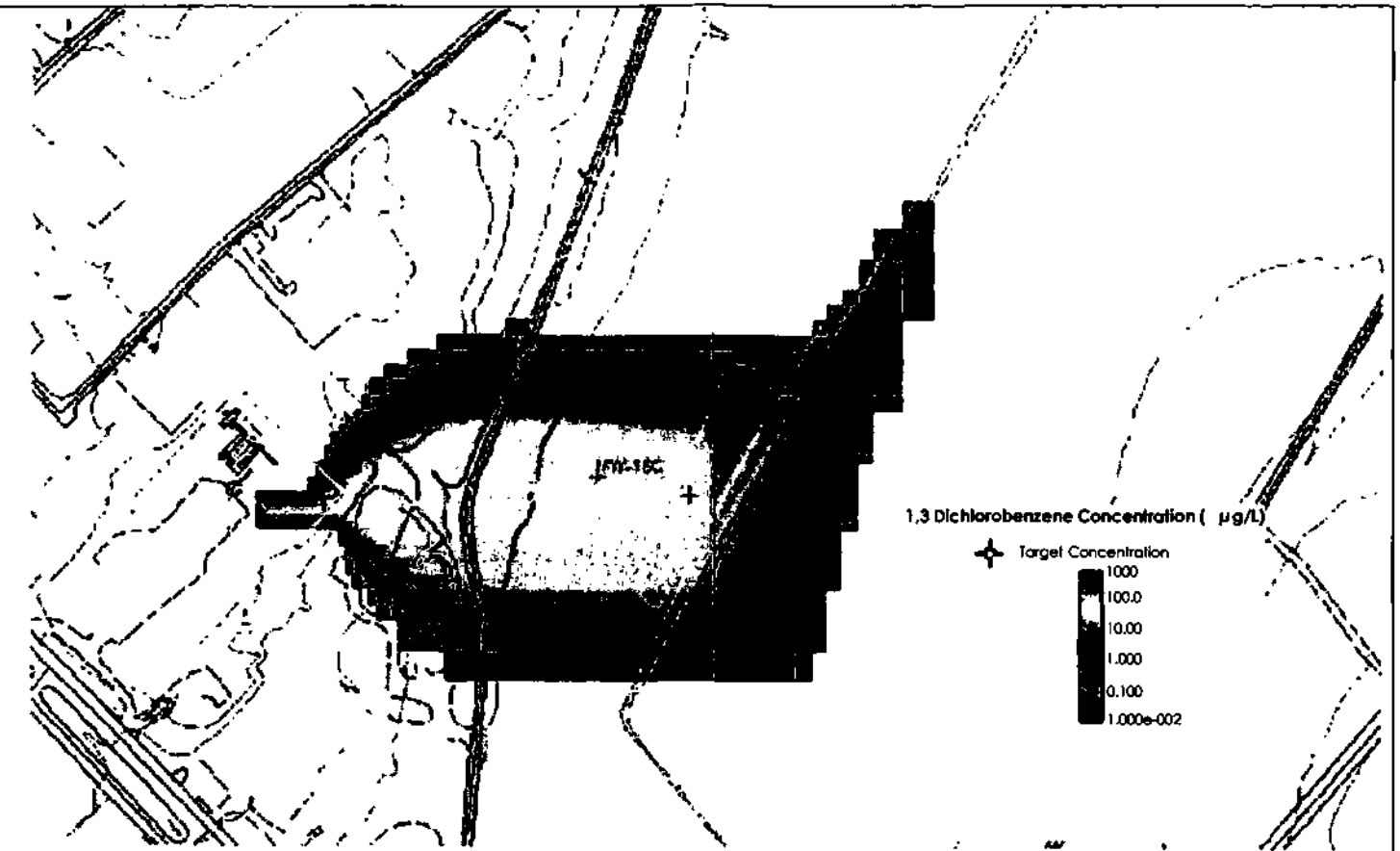


FIGURE 10 (C)

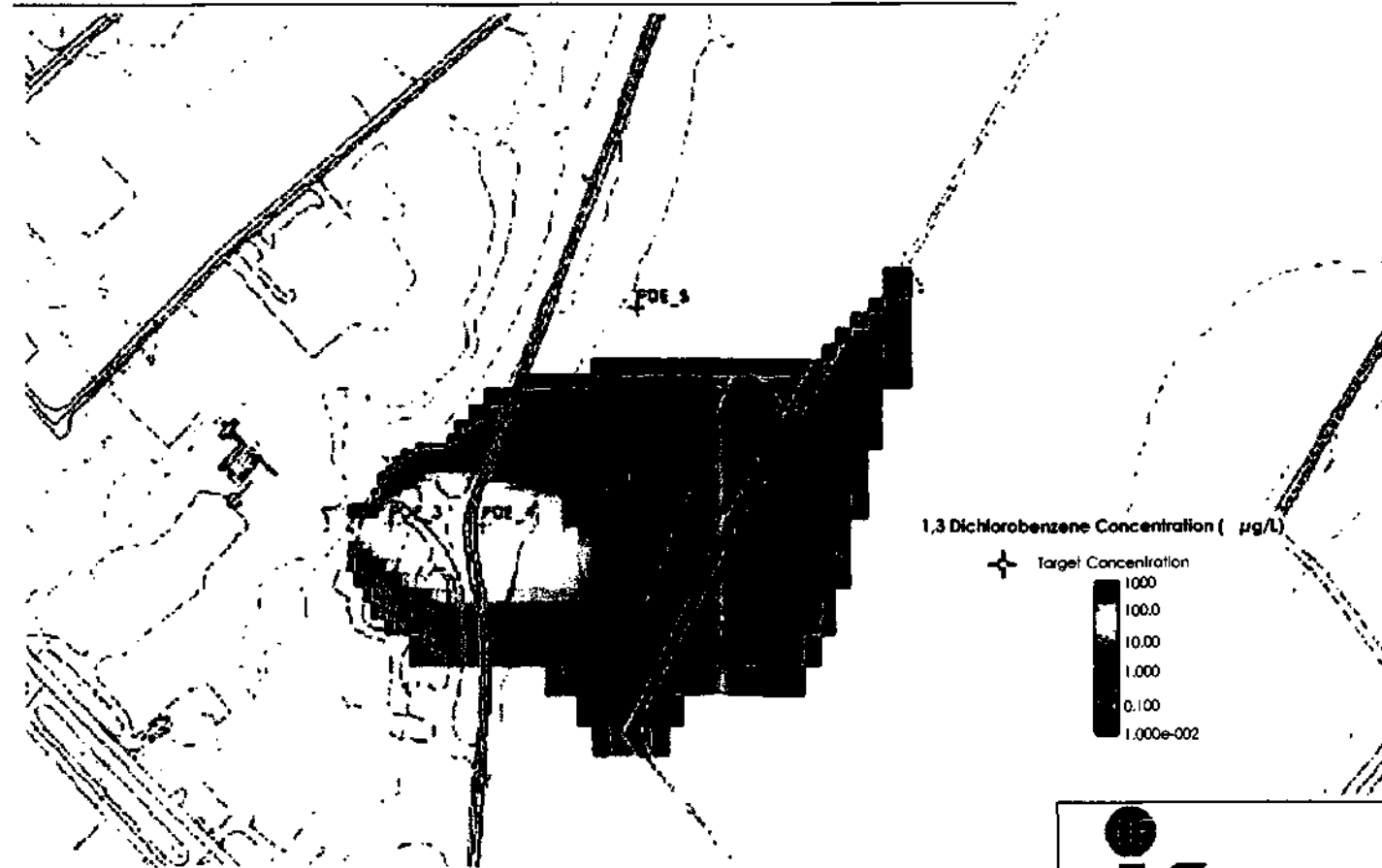


FIGURE 10 (B)

NOTES

1. (A) = shallow alluvium, layer 1.
2. (B) = weathered bedrock/deep alluvium, layer 2.
3. (C) = fractured bedrock, layer 3.
4. µg/L = micrograms per liter



Approximate Scale in Meters



MISSOURI ELECTRICAL WORKS CAPE GIRARDEAU

1,3 DICHLOROBENZENE PLUME MAP

CT 04/2005

JR H0931G

10

MEW Site File
3DISC104047

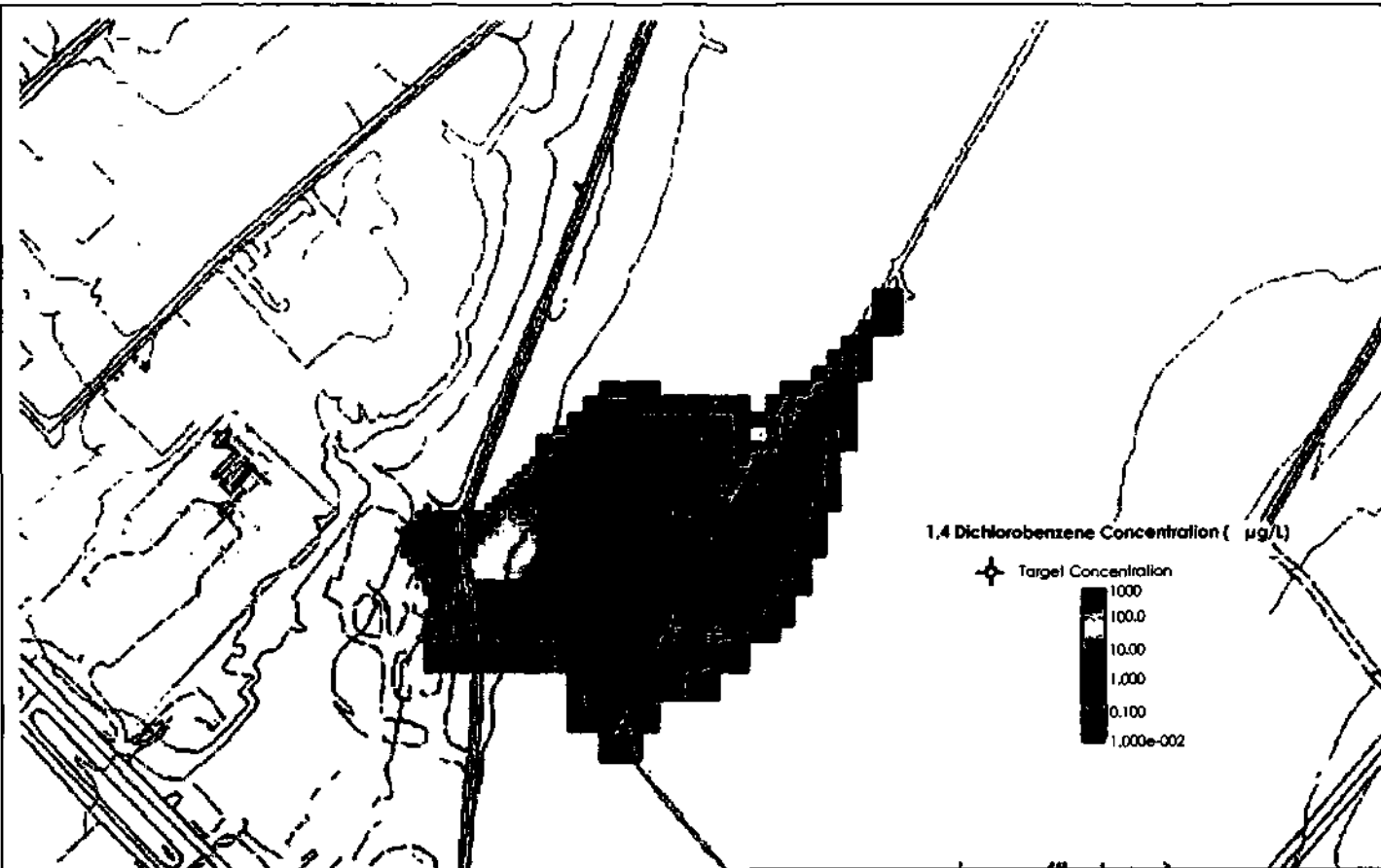


FIGURE 11 (A)

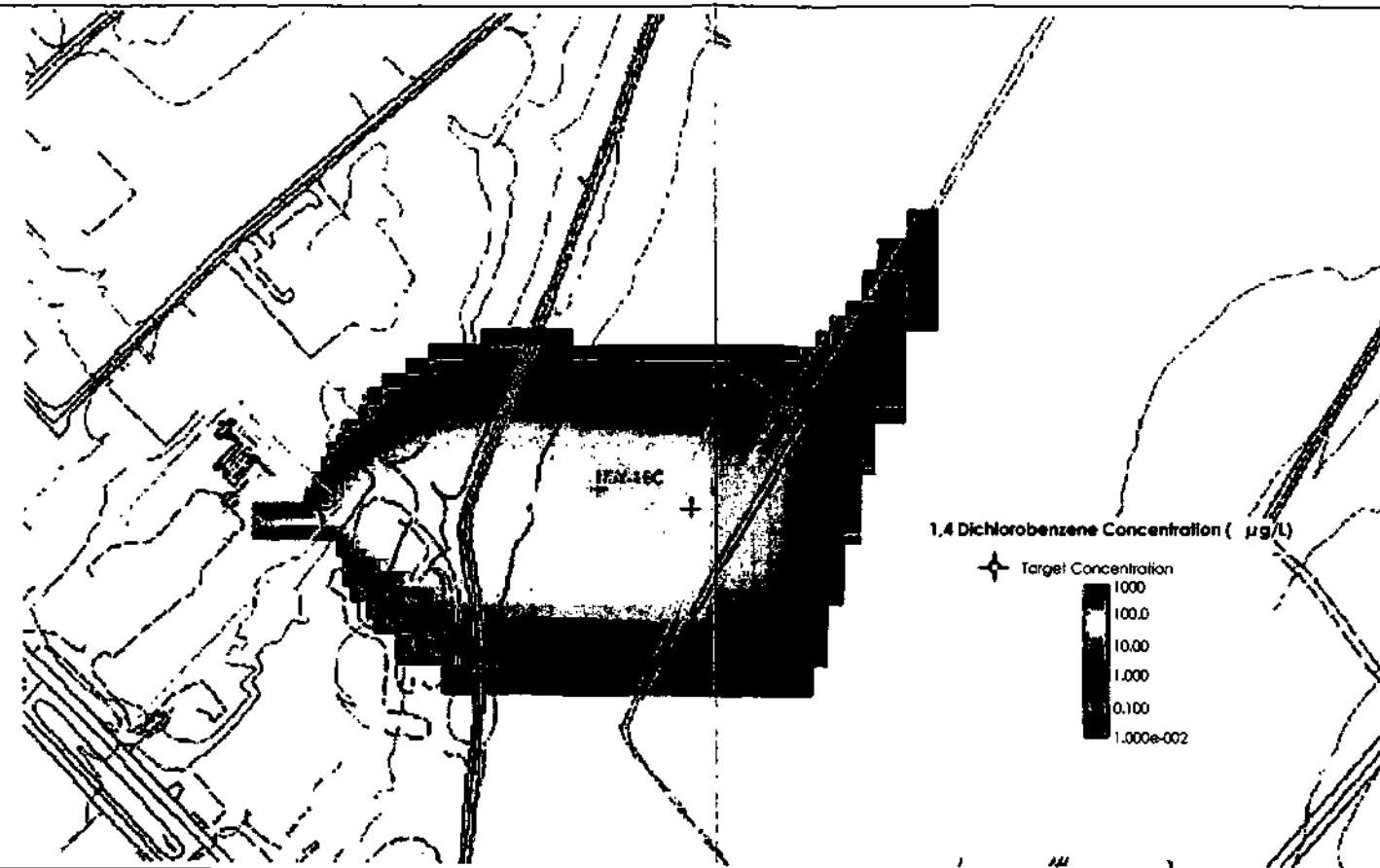


FIGURE 11 (C)

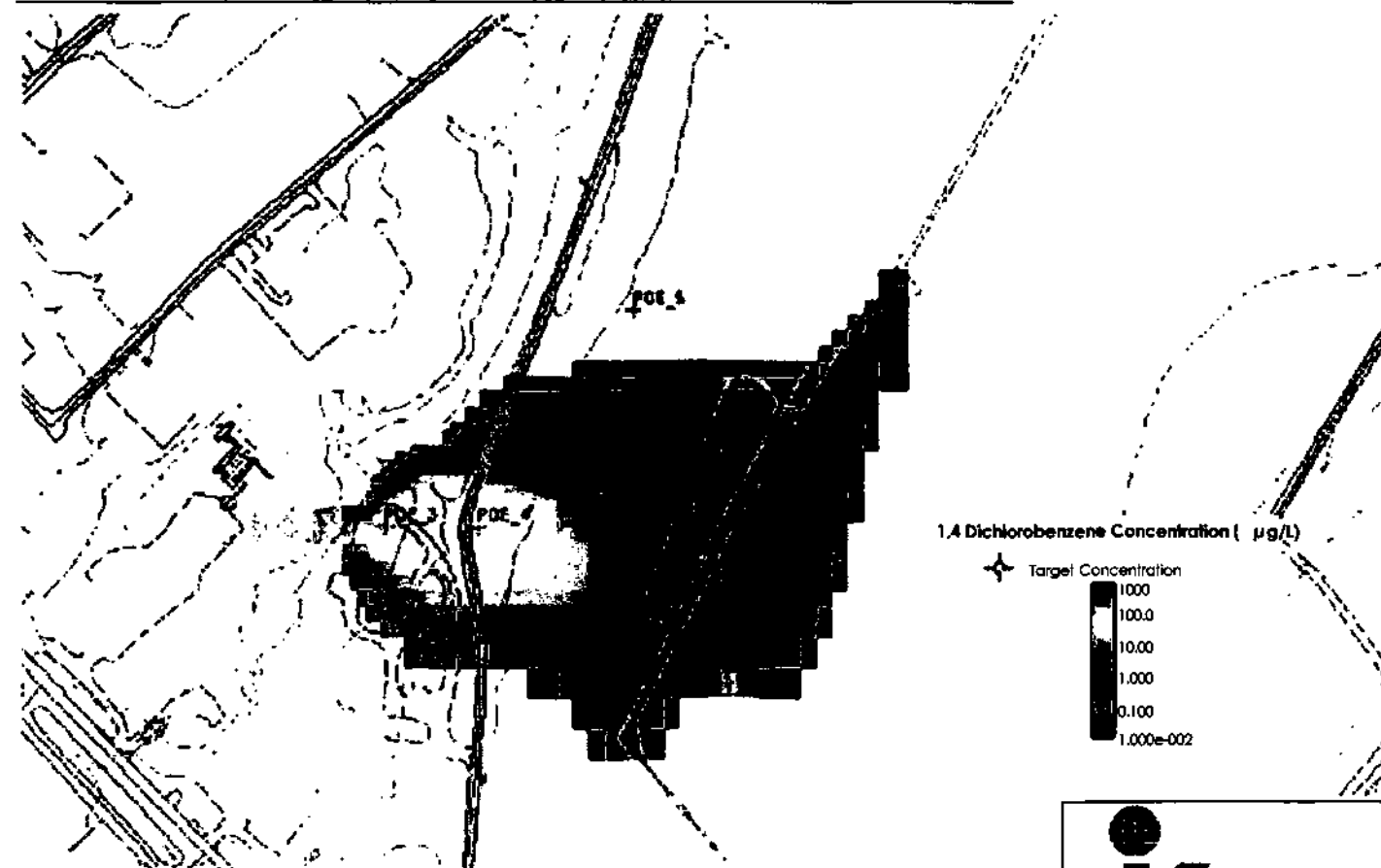
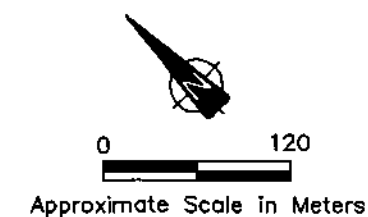


FIGURE 11 (B)

NOTES

1. (A) = shallow alluvium, layer 1.
2. (B) = weathered bedrock/deep alluvium, layer 2.
3. (C) = fractured bedrock, layer 3.
4. µg/L = micrograms per liter



MISSOURI ELECTRICAL WORKS CAPE GIRARDEAU

1,4 DICHLOROBENZENE PLUME MAP

CI 04/2005

JR H0931G

11

MEW Site File
3DISC104048

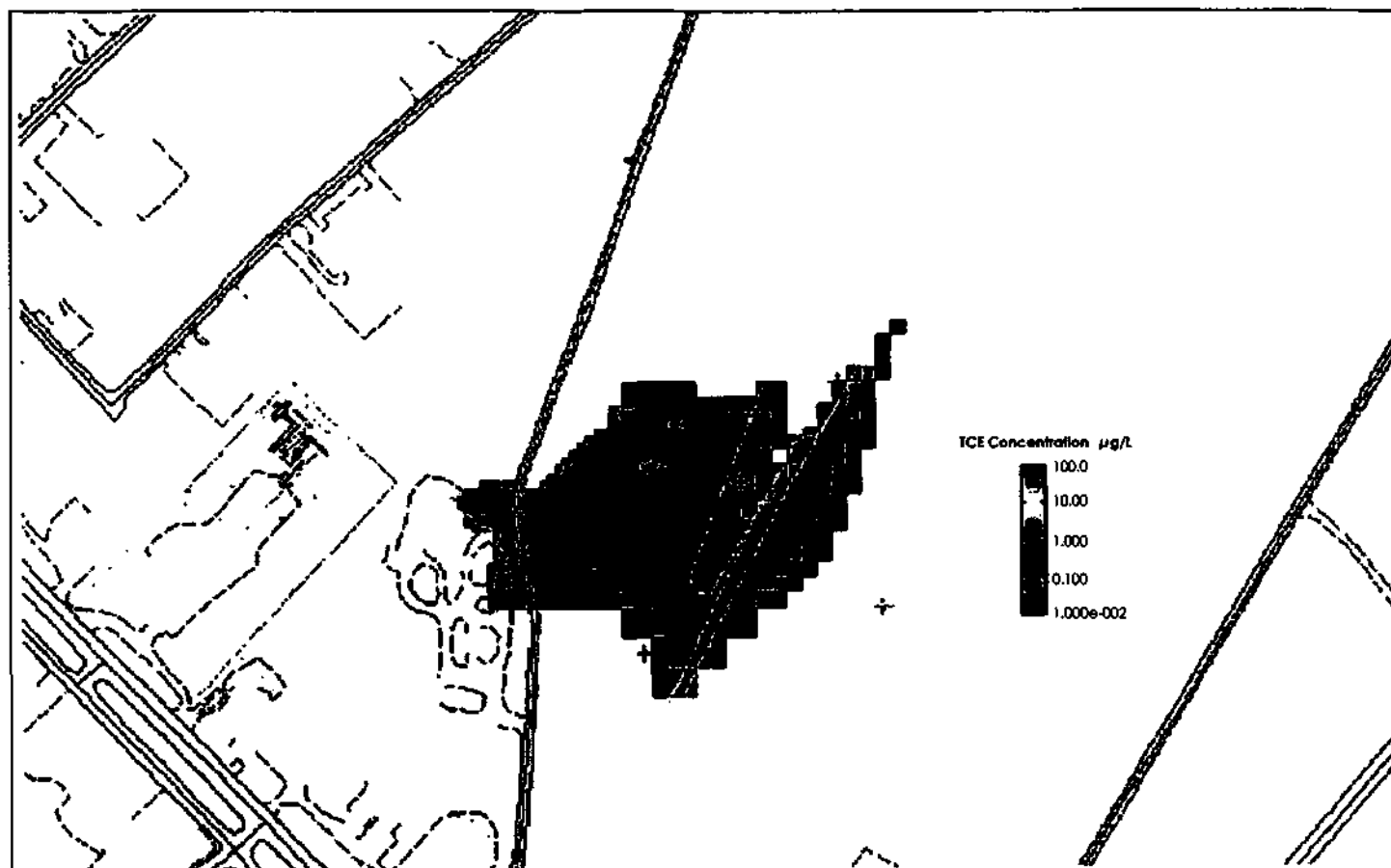


FIGURE 12 (A)

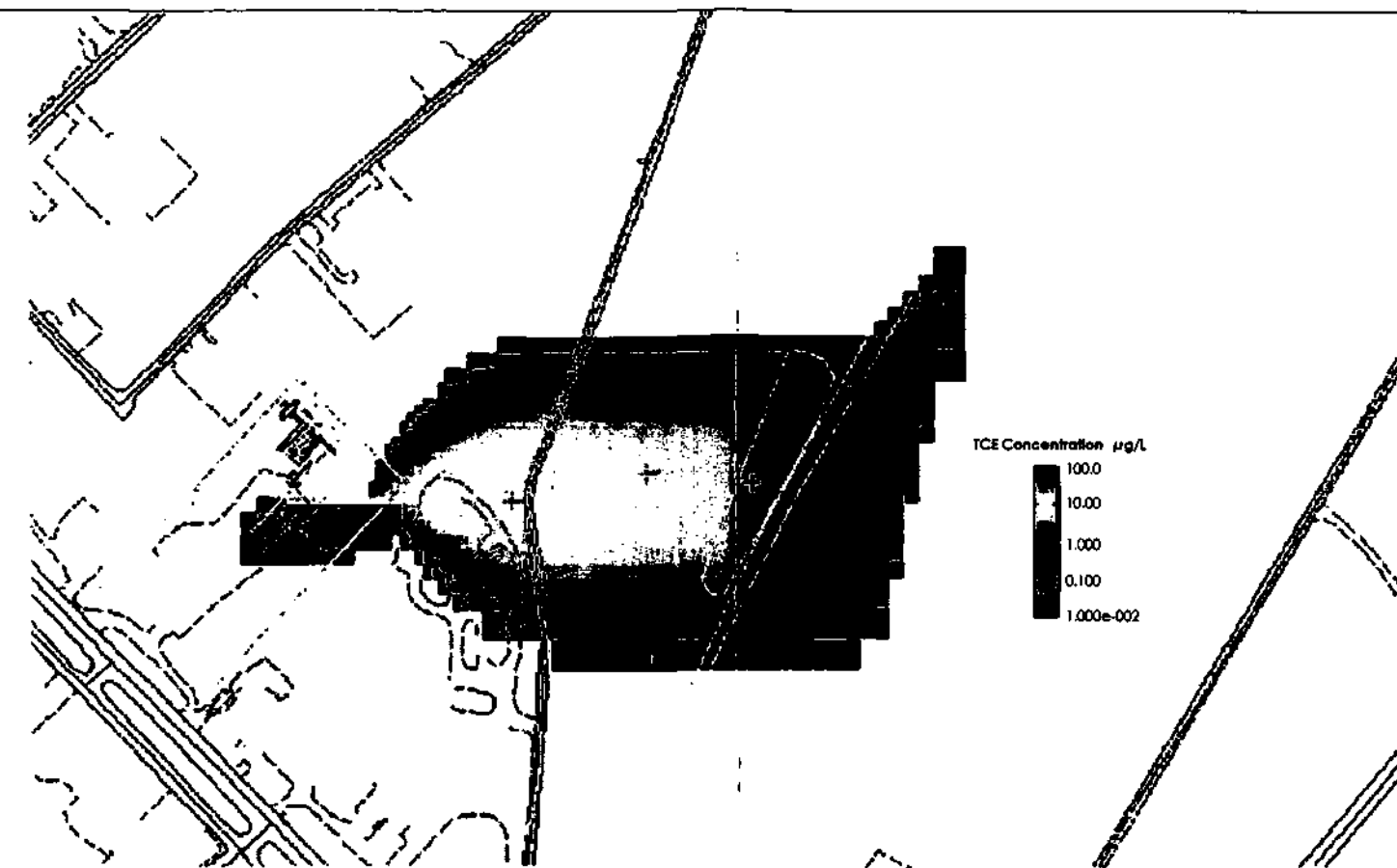


FIGURE 12 (C)

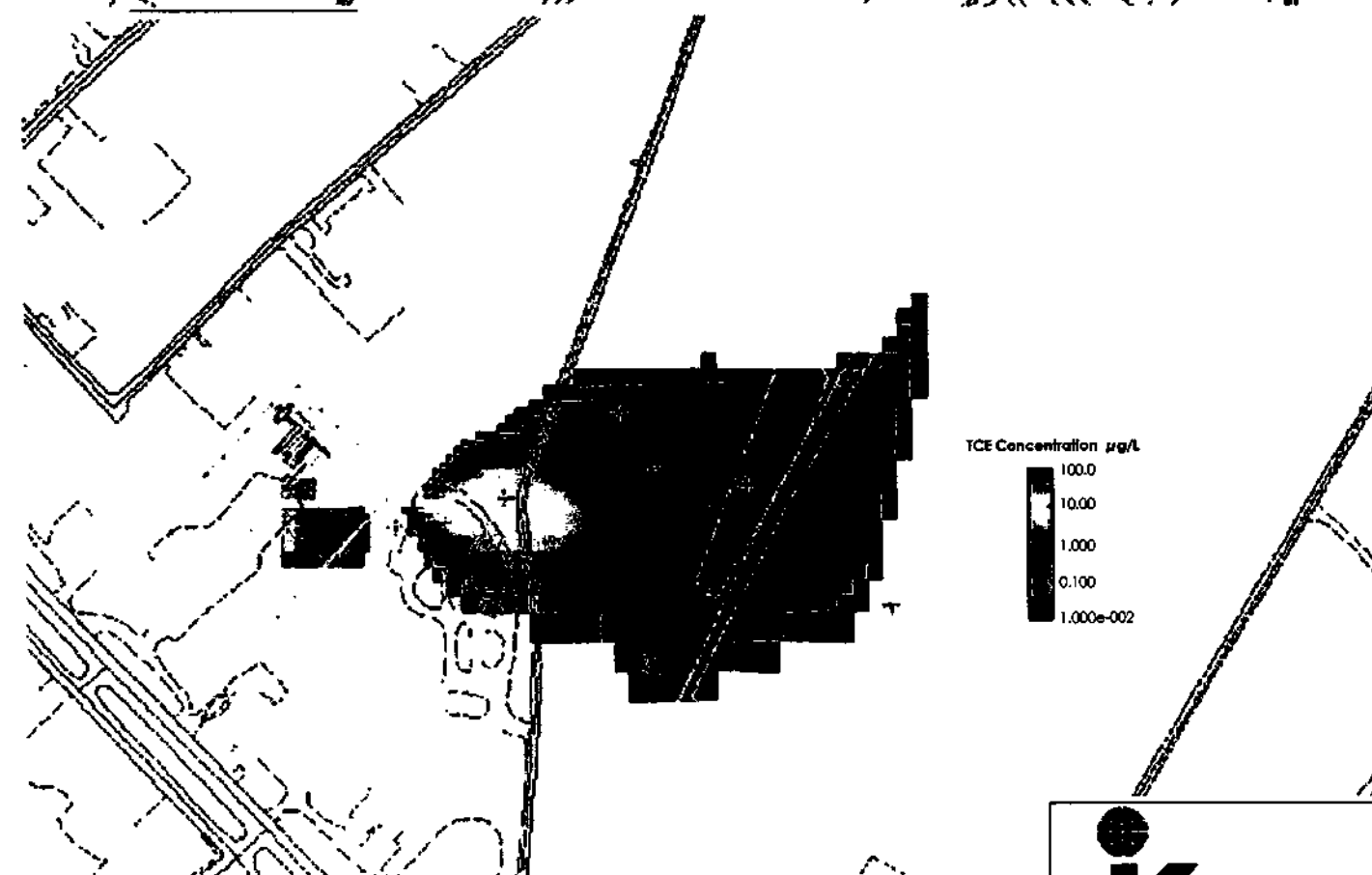
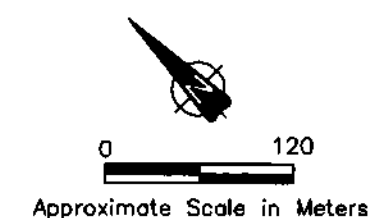


FIGURE 12 (B)

NOTES

1. (A) = shallow alluvium, layer 1.
2. (B) = weathered bedrock/deep alluvium, layer 2.
3. (C) = fractured bedrock, layer 3.
4. µg/L = micrograms per liter
5. TCE = Trichloroethylene



| | | | |
|--|--|----|---------|
| MISSOURI ELECTRICAL WORKS CAPE GIRARDEAU | | CT | 04/2005 |
| TRICHLOROETHYLENE (TCE) PLUME MAP | | JR | H0931G |
| | | 12 | |

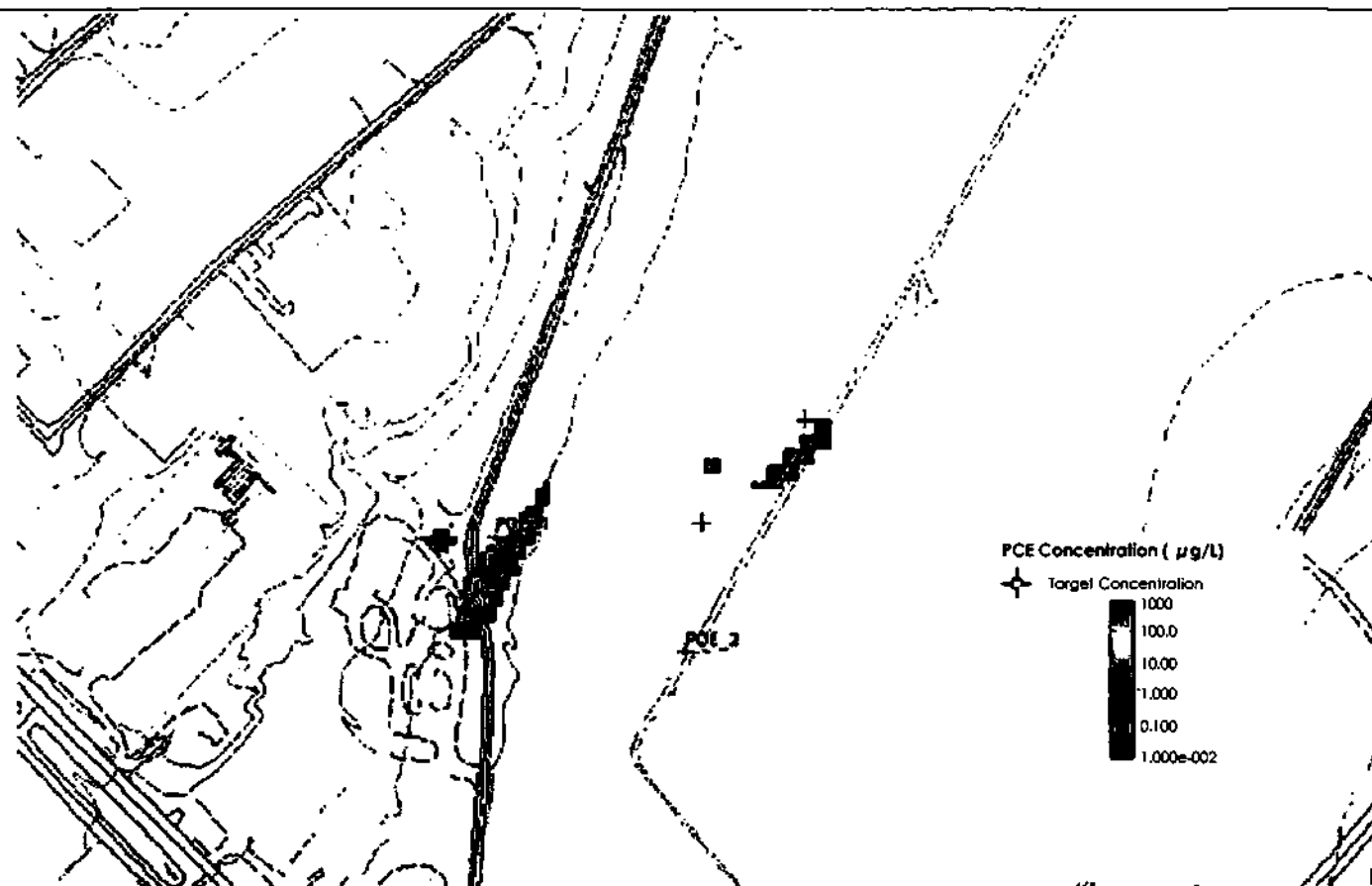


FIGURE 13 (A)

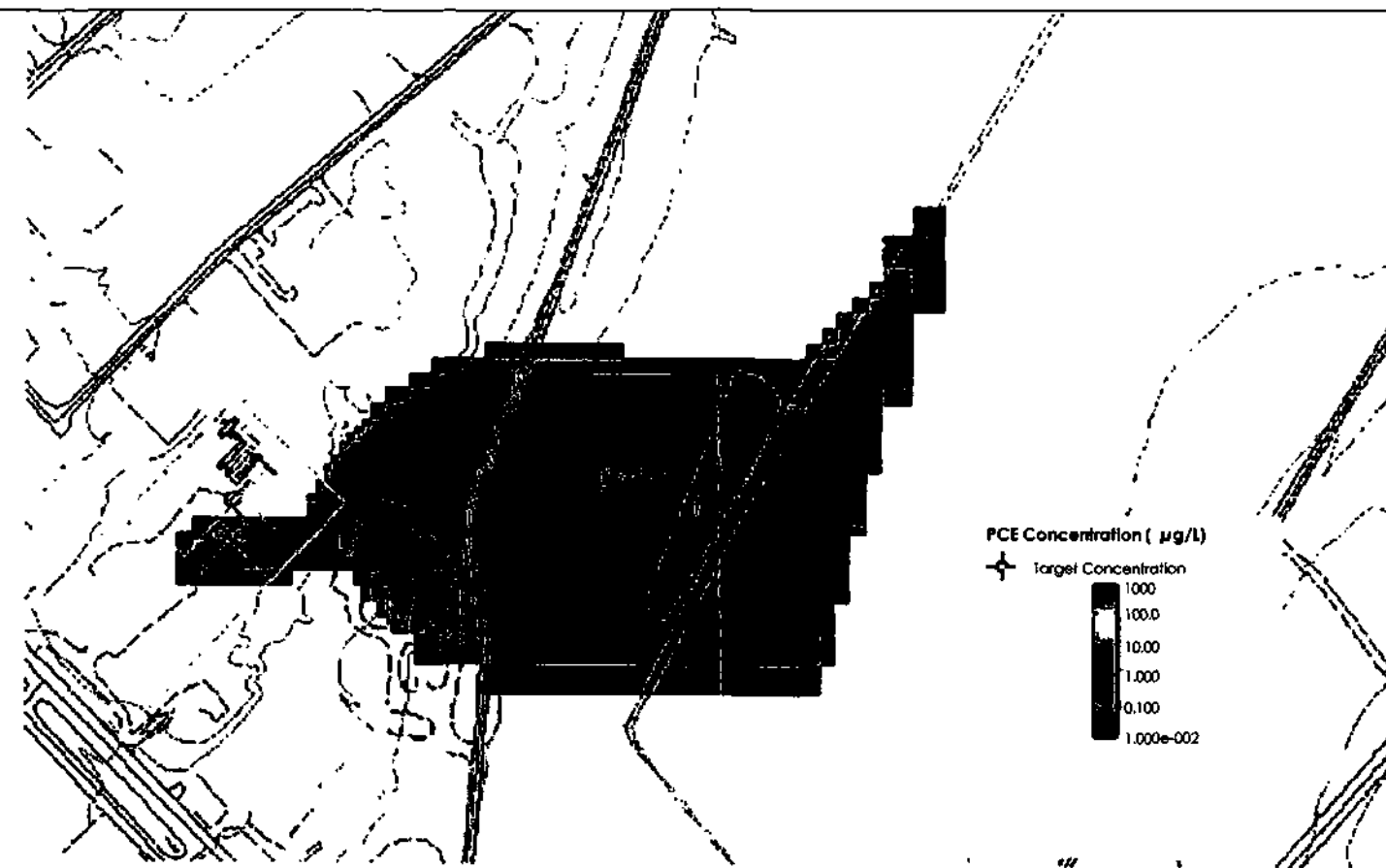


FIGURE 13 (C)

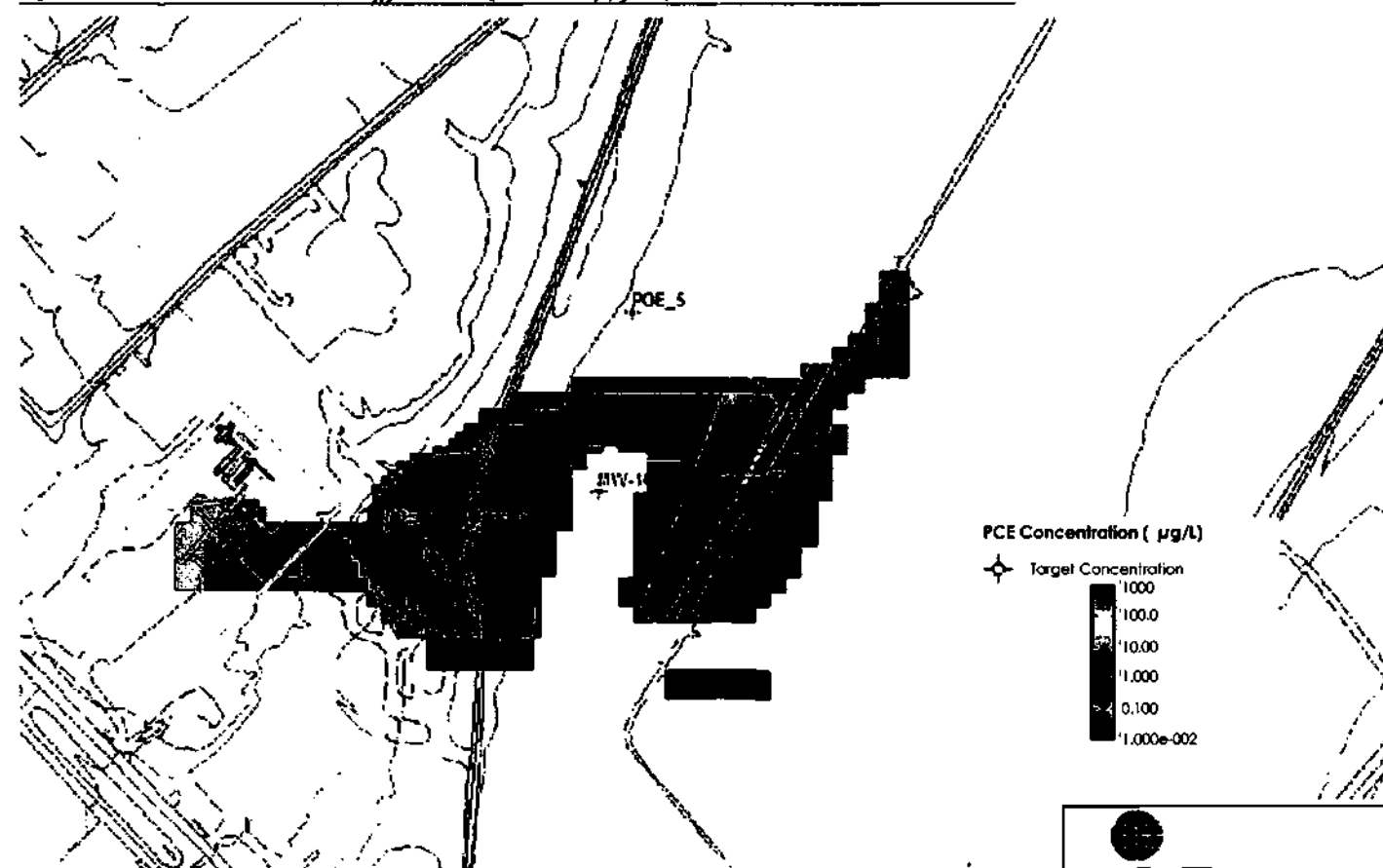


FIGURE 13 (B)

NOTES

1. (A) = shallow alluvium, layer 1.
2. (B) = weathered bedrock/deep alluvium, layer 2.
3. (C) = fractured bedrock, layer 3.
4. µg/L = micrograms per liter
5. PCE = tetrachloroethene



MISSOURI ELECTRICAL WORKS CAPE GIRARDEAU

PCE PLUME MAP

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MEW Site File
3DISC104050

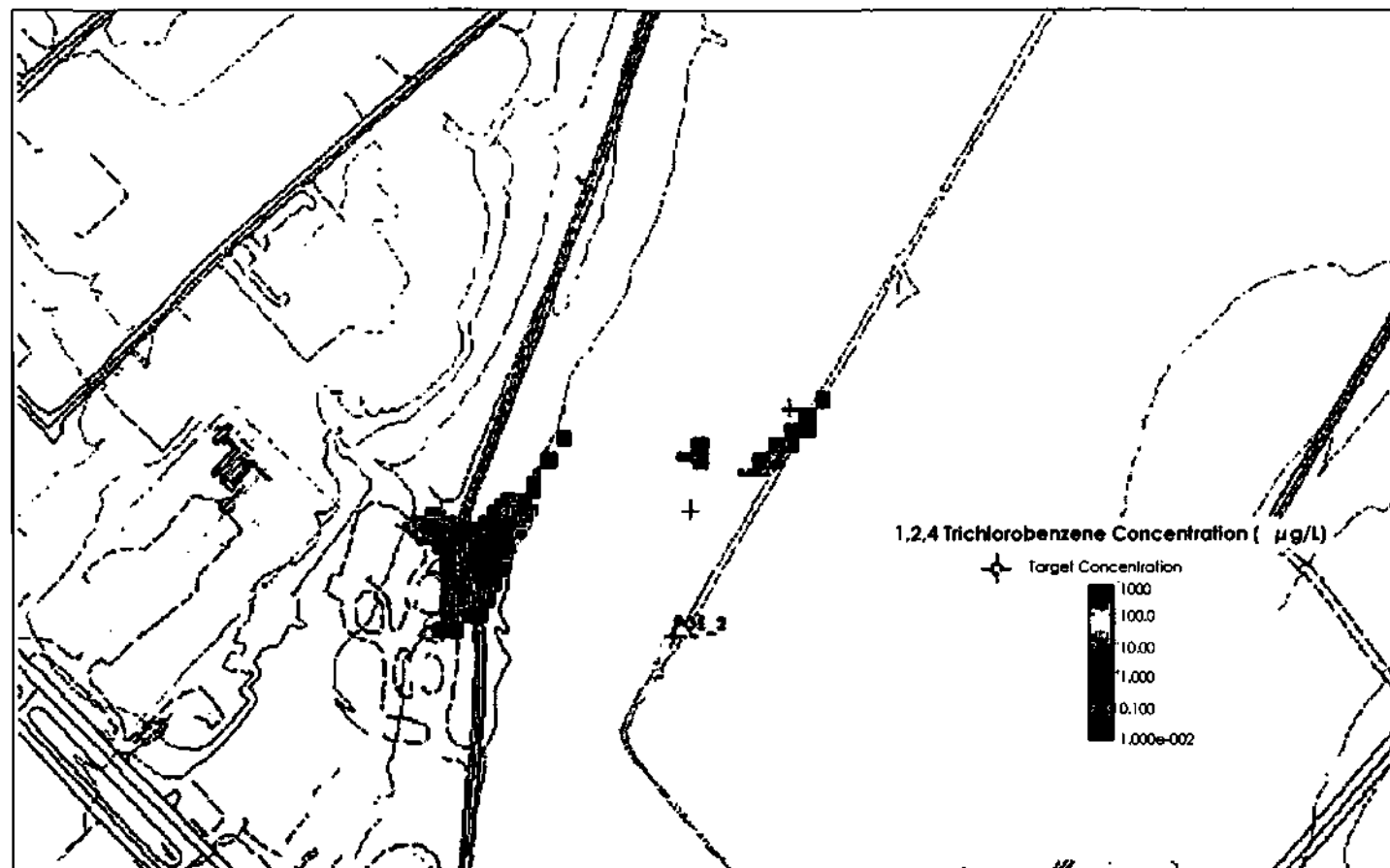


FIGURE 14 (A)

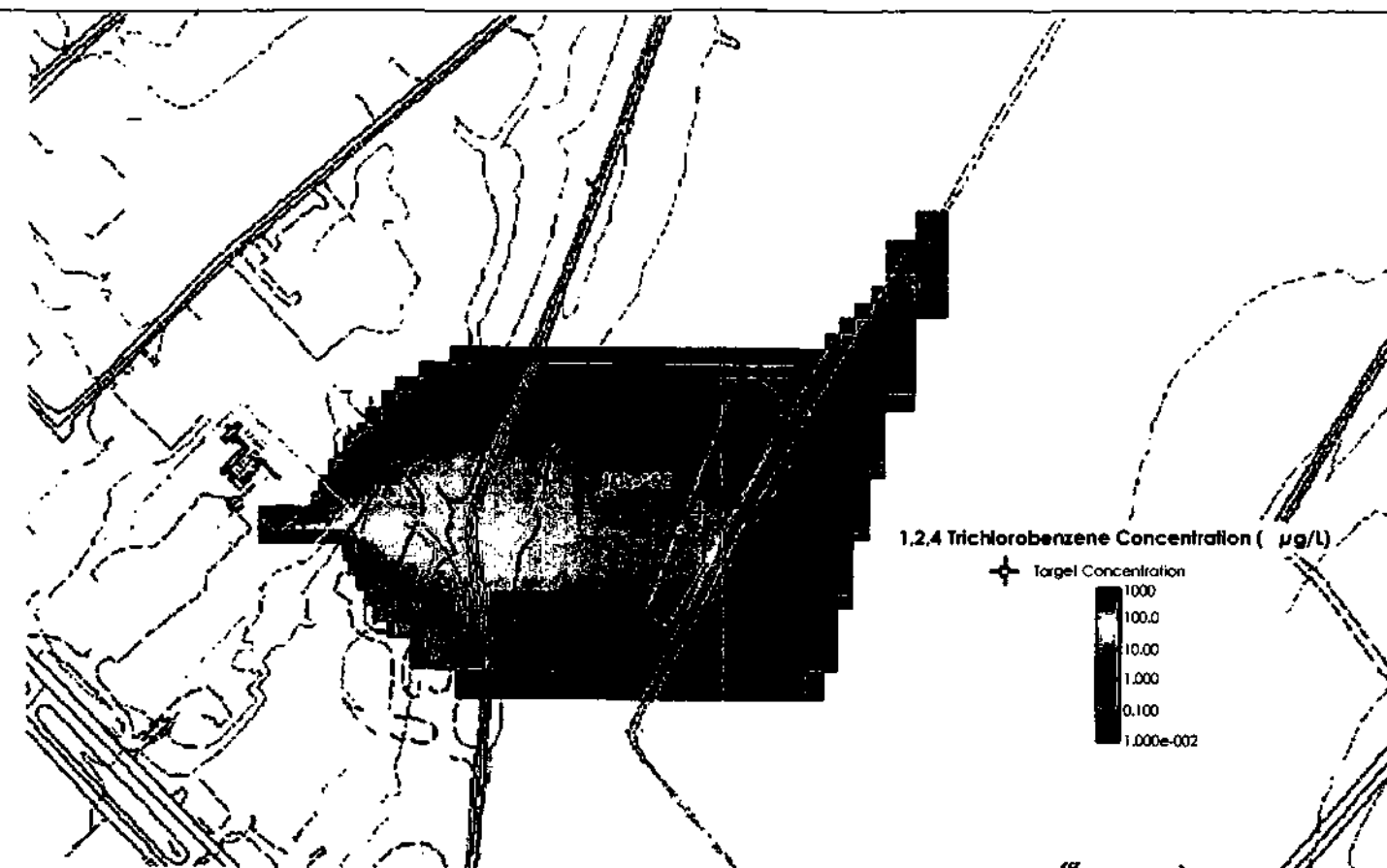


FIGURE 14 (C)

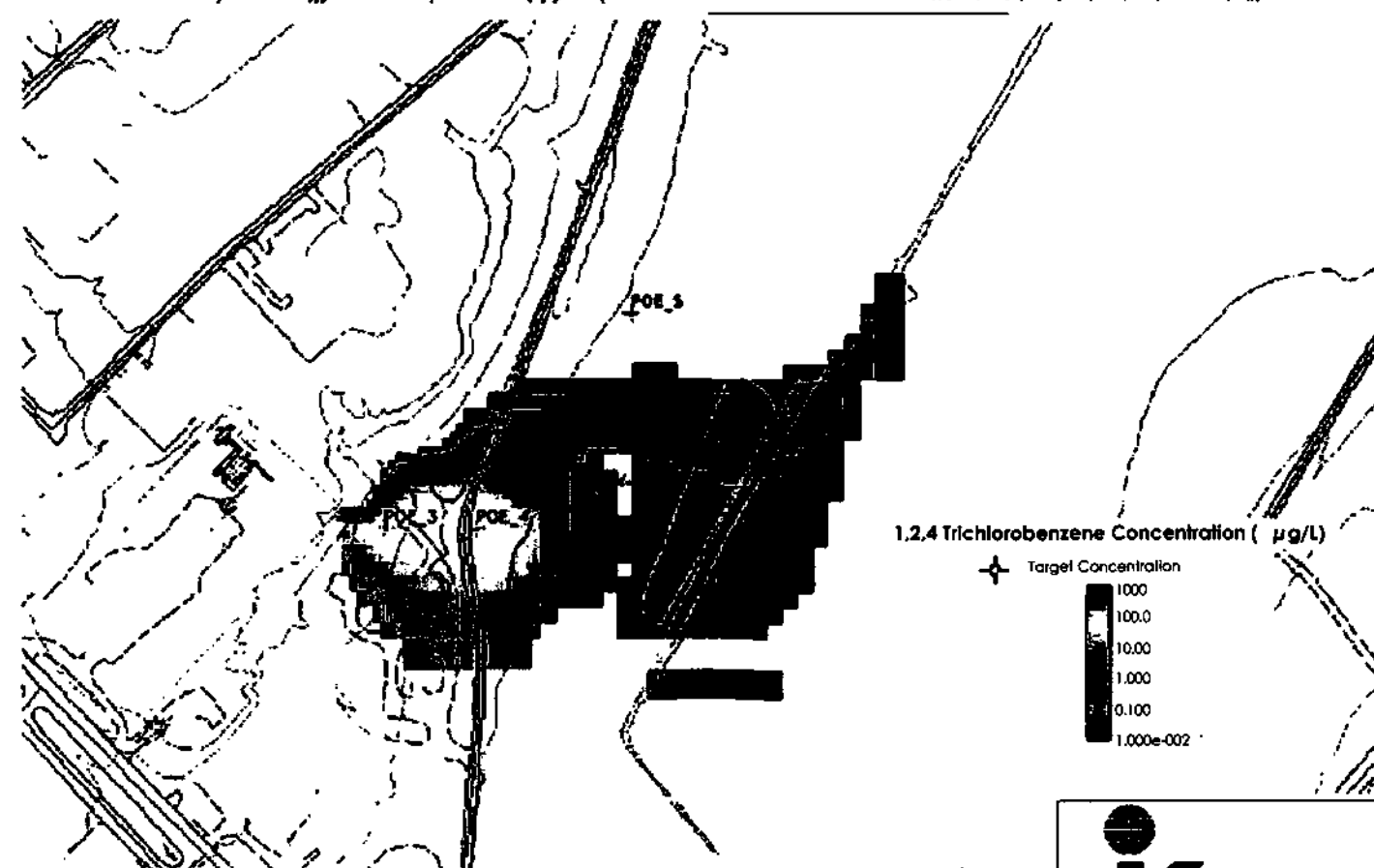
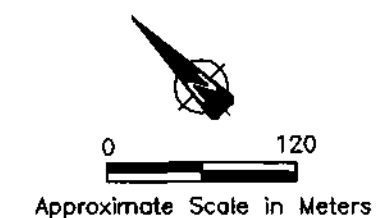


FIGURE 14 (B)

NOTES

1. (A) = shallow alluvium, layer 1.
2. (B) = weathered bedrock/deep alluvium, layer 2.
3. (C) = fractured bedrock, layer 3.
4. µg/L = micrograms per liter



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1,2, 4 TRICHLOROBENZENE PLUME MAP

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MEW Site File
3DISC104051

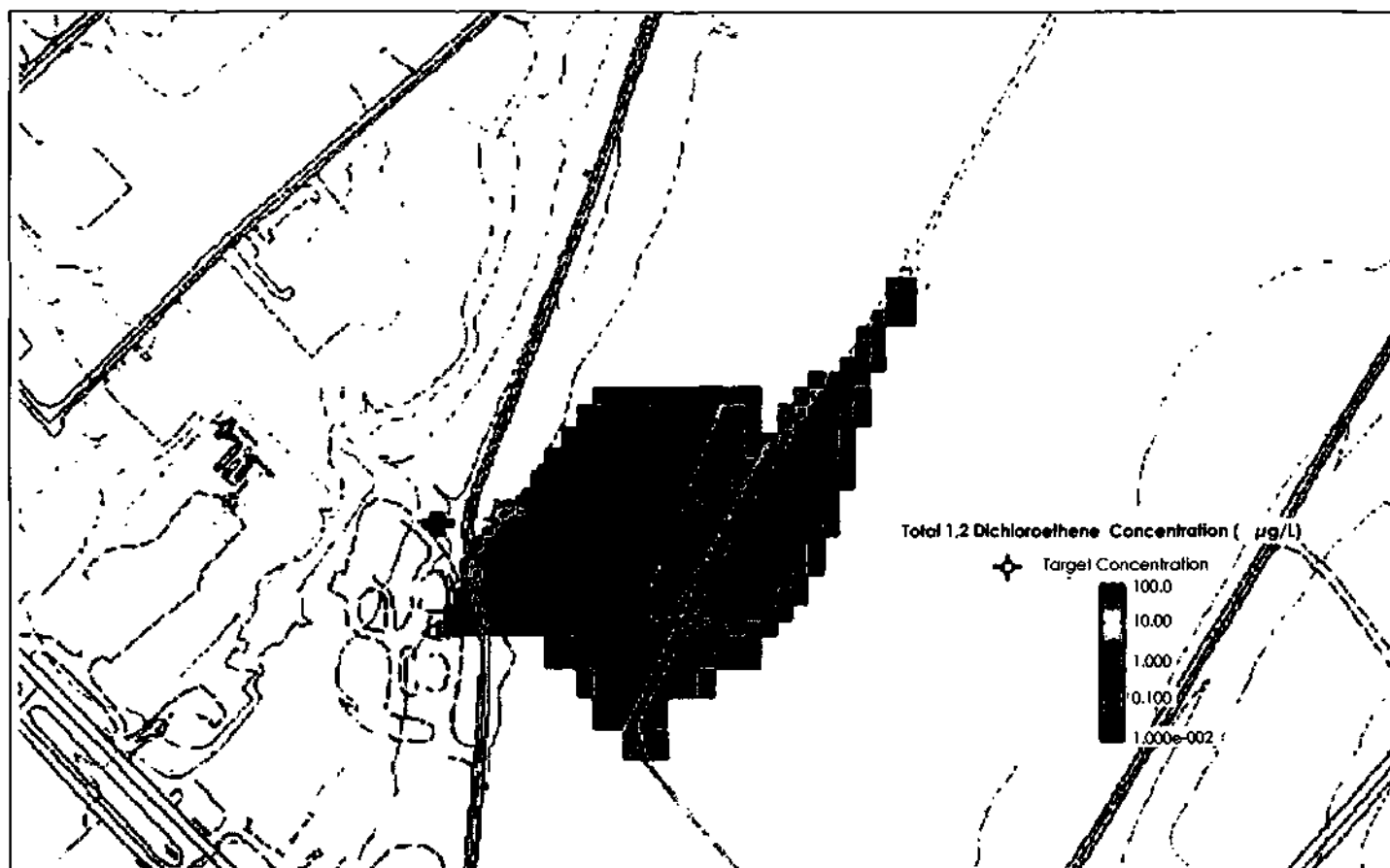


FIGURE 15 (A)

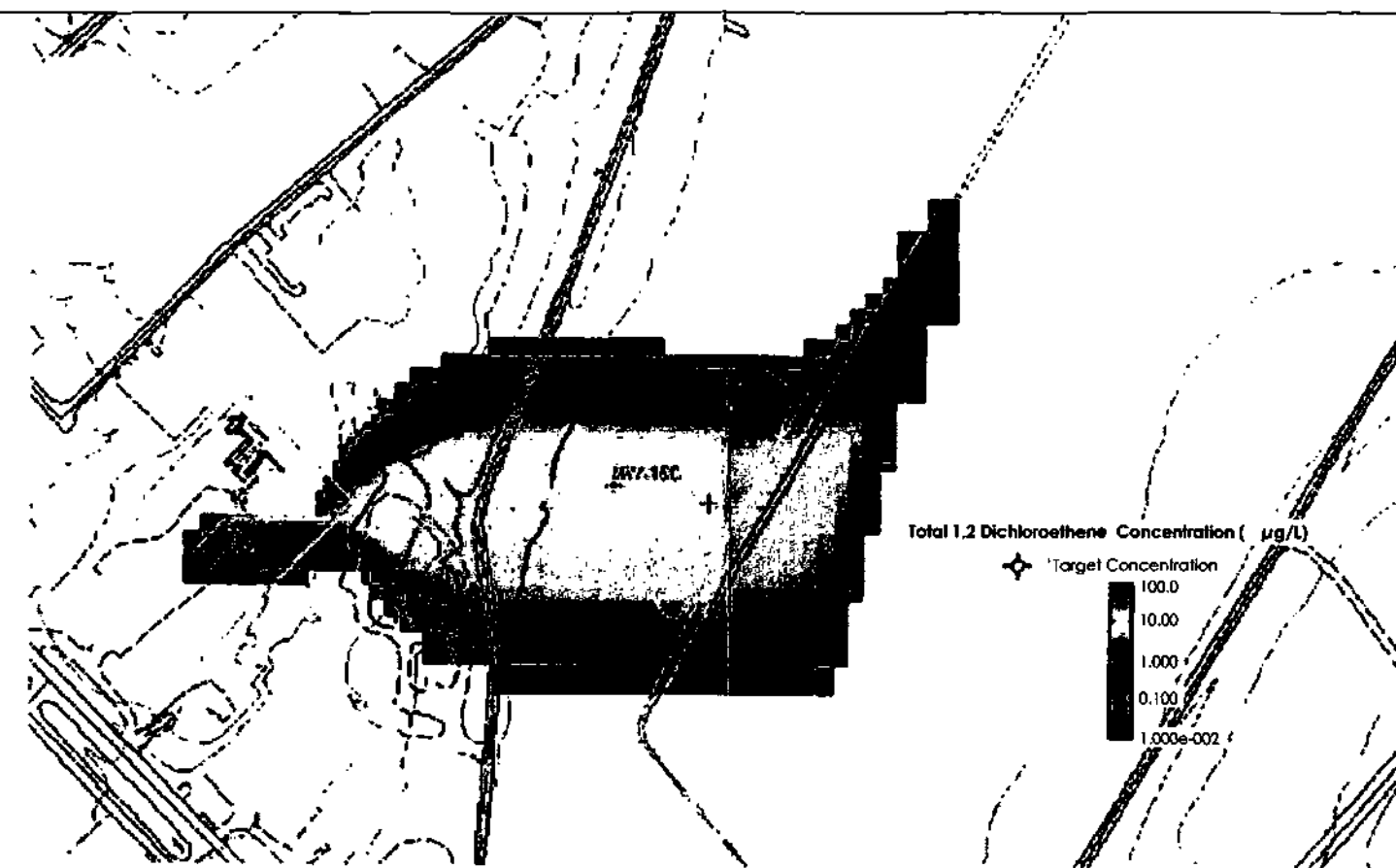


FIGURE 15 (C)

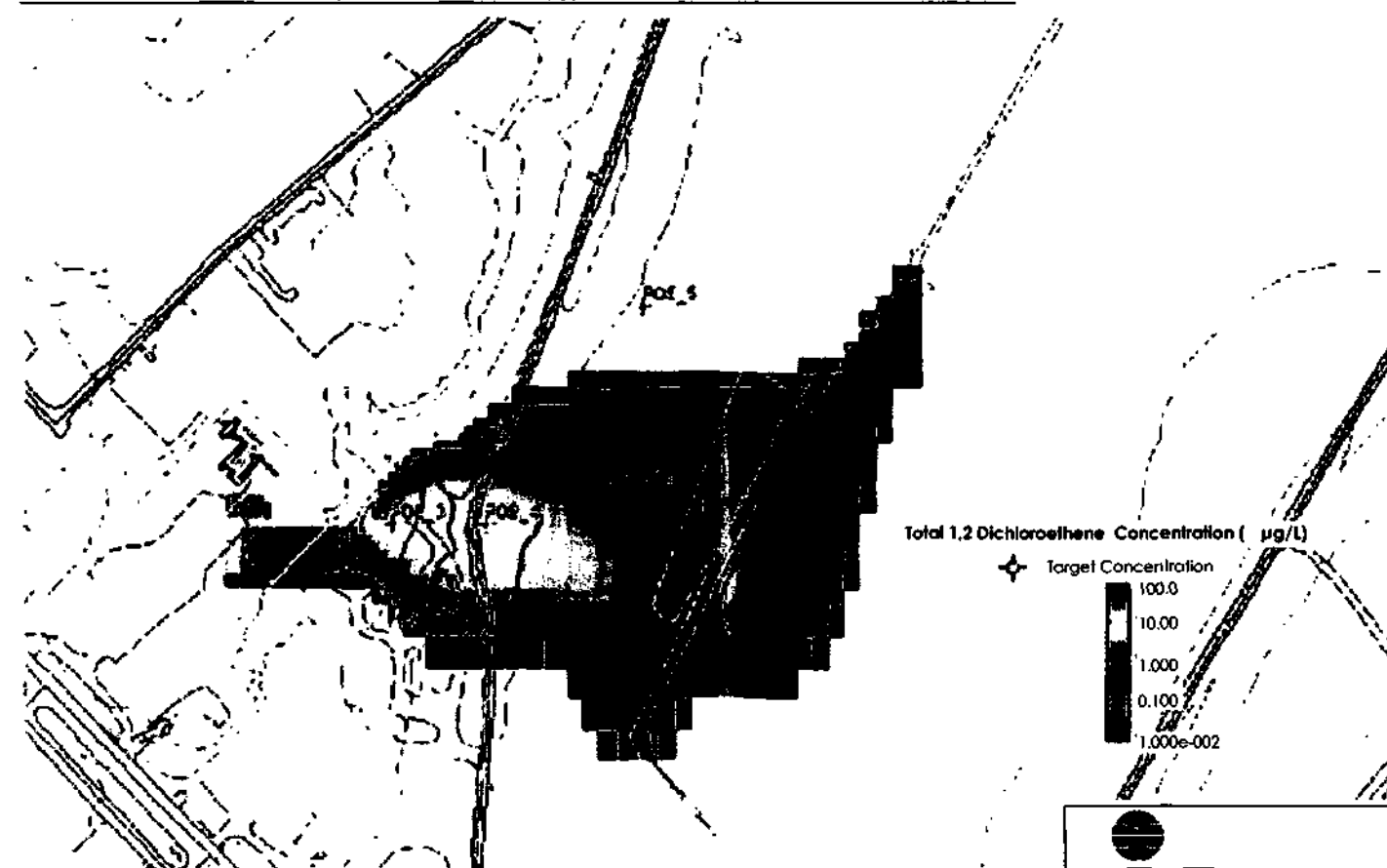
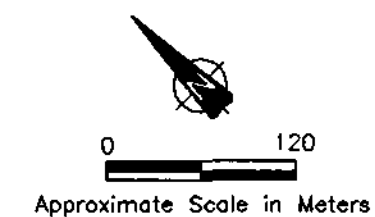


FIGURE 15 (B)

NOTES

1. (A) = shallow alluvium, layer 1.
2. (B) = weathered bedrock/deep alluvium, layer 2.
3. (C) = fractured bedrock, layer 3.
4. µg/L = micrograms per liter



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UNLESS THE ACT BEING DONE IS A SERVICE.

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TOTAL 1,2 DICHLOROETHENE PLUME MAP

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MEW Site File
3DISC104052